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Truly yours
E. Emmons

THE

AMERICAN GEOLOGIST

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BIOGRAPHICAL NOTICE OF EBENEZER EMMONS.

By JULES MARCOU, Cambridge, Mass.

The founder of American palæozoic stratigraphy and the first discoverer of the primordial fauna in any country, Dr. Ebenezer Emmons, was born at Middlefield, Massachusetts, May 16, 1800. He received the Puritan education of the communities and families of New England, which influenced him through life, giving him an apparent severity and sternness of manners, although in reality of a cheerful and playful disposition. Without being in the least melancholy, he was distant in his manner, and being deeply religious, he enforced in his family strict Puritan discipline. For instance, with him "Sunday commenced Saturday evening at sundown and did not end until Monday morning, and it was considered sinful to laugh at any time during this interval," as one of his children wrote me.

Emmons prepared for college at Plainfield, Mass., under Rev. Mr. Halleck, and during his vacations his time was mostly spent among the Middlefield and Chester rocks, collecting minerals and also making collections of insects and plants. He entered Williams college at the age of sixteen, and graduated in the class of 1820. During his stay at college, he became the favorite pupil of C. Dewey, the professor of natural history, and a short time after, when a medical student at Albany, he became acquainted with the geologist, professor Eaton.

After graduation Dr. Emmons practiced medicine and surgery in Berkshire county fifteen years, and during that time performed

many grave and difficult surgical operations with notable success; he was also considered the most reliable medical practitioner in the county. After being appointed professor of chemistry at the Albany Medical college in 1838, he continued his connection with that institute until 1852, when he resigned his professorship of chemistry in favor of Dr. Lewis Beck (the mineralogist of the geological survey of New York), and assumed the professorship of obstetrics, in which branch of medical instruction he was eminent.

But his chief interest was in geology, and as far back as 1824, he is mentioned by professor C. Dewey as his assistant for the construction and description of "A Geological map of the County of Berkshire, and of a small part of the adjoining states," the first truly geological attempt to systematize and classify with details the rocks of the Taconic area.

From his graduation at Williams college in 1820, Emmons constantly explored the hills of Berkshire, making always geological observations in his constant rambling over the county, as a country medical practitioner, and using his opportunities in Williams college as lecturer and professor, to survey minutely every part of the area of Berkshire. As early as 1828, he was lecturer on chemistry at that institution, and in 1833 he was appointed professor of natural history as successor of his teacher, professor C. Dewey. I should say, in order not to break his record at Williams college, that in 1854, his professorship was called chair of natural history and geology, and after 1859 until his death in 1863, he held the title of professor of geology and mineralogy. To Emmons is due mainly all the collections in natural history of that celebrated institution of learning.

His appointment as geologist of the "Second District" of the geological survey of the state of New York, in July, 1836, gave the opportunity for the exercise of his power of acute observation in the field, and as a classifier of geological data, which made his great and just reputation. The state of New York was divided into districts, and the following geologists were appointed: William W. Mather for the first district, professor E. Emmons for the second, T. A. Conrad for the third and Lardner Vanuxem for the fourth. These appointments of governor W. L. Marcy were excellent. Emmons, Conrad and Vanuxem were all three very remarkable observers and classificators of the first order.

Vanuxem was the first foreign student admitted without exami-

nation at the School of Mines in France, through the influence and patronage of general Lafayette, and during his stay in Paris, he profited by the great and unique advantage, then existing. of following the lectures of such naturalists as: Alexander Brongniart, l' abbé Hauy, George Cuvier, Geoffroy St. Hilaire, Brochant de Villiers and Berthier. Having returned to America, Vanuxem devoted himself to mining pursuits, but with a constant lookout for geological researches, and it was he who made the first modern classification of our rocks, after the old Wernerian classification of MacClure. To Vanuxem we owe the discovery of the Cretaceous system and the exact classification as Transition strata of all the beds regarded then as "Secondary" in the states of New York, Ohio, Kentucky, Tennessee and Virginia. He saw at once that the classification of professor Eaton of all the rocks of the four district areas, from Otsego and Tioga to Erie and Niagara counties, as very modern secondary groups, was untenable and incorrect, and to him is due the exact classification of the strata of the fourth and in part also of the third district.

Conrad, a very able conchologist of the Lamarck and Deshayes school, called at once the attention "to the importance of a knowledge of organic remains" for the classification of the New York strata; and in his first report, of 1836, issued February, 1837, he gave a good general classification of the principal masses of strata from the Calcareous sandstone of the Mohawk valley to the Onondaga limestone series. Appointed palæontologist of the state survey, he helped to give more details to the classification and nomenclature made and used, until he left the survey in 1841, on account of poor health,—a great and irreparable loss, which has weighed heavily ever since on the progress of American palæozoic palæontology and geology.

But to Emmons is due the most difficult part of the geological survey of New York, and to him mainly we owe the very remarkable classification of the New York strata into two great series or systems, the Taconic system and the New York system. And to him also is due the division of the New York system into four great divisions or series, the Champlain, Ontario, Helderberg and Erie.

As soon as appointed state geologist, Emmons searched for an assistant acquainted with mineralogy to help him to survey the iron ores abundantly distributed in the second district. He wrote

to his friend Dr. Charles T. Jackson, of Boston, to know if he could recommend a young mineralogist for the position. Jackson designated the son of a miller of the village of Hingham, near Boston, named James Hall, who used to come often to his office, bringing with him minerals to determine and borrowing books. Acting on the recommendation of Dr. Jackson, Dr. Emmons appointed James Hall for his assistant, and during the first season of the survey Mr. Hall gave much of his attention to the ores of iron in the northern district of New York.

During the second season of exploration, Dr. Emmons named, described, and classified the *Potsdam sandstone*, so celebrated since. The first time that the "Sandstone of Potsdam" is used in geology is at p. 214 of the second annual report of the "2nd Geological District" of the state of New York, by Emmons, 1838. Notwithstanding the excellent description given by Dr. Emmons, never has a well defined group of strata been so little understood and so erroneously made use of. Beds ranging from the *Paradoxides* argillites of Braintree inclusive to the Triassic sandstone of lake Superior, have been referred to it, at random, without the smallest appearance of identity or even of close affinity.[1]

In 1838 Dr. Emmons began to make observations which led him in 1842 to create below the Potsdam sandstone the great Taconic system, composed of a series of strata twenty-five to thirty thousand feet thick. At first he did not find fossils, but two years later he published his memoir on "the Taconic system" with fossils unknown in any other system and as he says, "peculiar to the black and the Taconic slates." The discovery of Taconic fossils was made in September, 1844, near Bald mountain, in the state of New York, and they were published in December of the same year at Albany, under the names of *Atops trilineatus*, *Elliptocephala asaphoides*, *Nemapodia tenuissima*, and *Fucoides (graptolites) simplex*. It was the first discovery and description of the Primordial fauna, all the world over; a discovery proved by dates and advocated by Barrande, the first authority on the Lower Palæozoic palæontology. ("On the use of the name Ta-

[1]The identification of rocks to the Potsdam sandstone of Emmons, constitutes a singular chapter in the history of the progress of American geology. Even to this day, we have the curious spectacle of a Head of Division of the U. S. Geological Survey who contrives to refer to the Potsdam, any strata of the Taconic system, whenever wanted at any special and convenient place to suit the purely imaginative and ever changing classification of his so-called American Cambrian.

conic," by J. Marcou, *Proceed. Boston Soc. N. H.*, vol. xxiii, March 2, 1887).

The volume issued in 1842, at Albany, of the "Geology of New York, Part II, comprising the survey of the Second Geological District," by Dr. Ebenezer Emmons, gave an excellent description of all the strata from the Potsdam sandstone to the termination of the Lorraine shales in a grey sandstone called Oneida conglomerate and sandstone. In this volume we have what we can call the germ of the "Taconic system," below the "New York Transition system," at chapters VII, VIII and IX, pp. 135-164. With the greatest honesty, which always characterized the scientific researches of Dr. Emmons, and with great courtesy, he made apology for stepping over the bounds of the second district and encroaching on the first district. Emmons says that: "He does not expect to be able to give full justice to the subject," only claiming "the merits, to a certain extent, of removing some of the obscurities which envelope this system of rocks." . . . . "They form a belt whose width is not far from fifteen miles along the whole western border (of the county of Berkshire, Mass.), and which extends clearly to the western base of the Taconic range."

At the end of the volume, p. 429, we have the most important and very well balanced classification of the palæozoic rocks in New York, which shows how Emmons was able to grasp all the difficulties—and they were numerous, and some very great—of the division, classification and nomenclature of the palæozoic rocks of North America.

TABULAR VIEW OF THE SEDIMENTARY ROCKS OF NEW YORK.

Taconic System. . . . Taconic slate, Magnesian slate, Stockbridge limestone, Granular Quartz.

NEW YORK SYSTEM.	Champlain Group.	Potsdam sandstone, Calciferous sand rock, Chazy and Birdseye limestone, Marble of Isle La Motte, Trenton limestone, Utica slate, Loraine shales, grey sandstone, conglomerate.
	Ontario Group.	Medina sandstone, Green shales and Oölitic iron ore, Niagara limestone, Red shale, Onondaga salt and plaster rocks, Manlius waterlime.
	Helderberg Series.	Pentamerus limestone, Delthyris shaly limestone, Oriskany sandstone, Encrinal limestone, Caudagalli grit, Schoharie grit, Helderberg limestone.
	Erie Group.	Marcellus and Hamilton shales, Tully limestone, Genesee slate, Ithaca and Chemung shales and grits.

Below, Emmons adds the Old Red system, the New Red system, and the Tertiary or blue and yellowish clays of Champlain. To Dr. Emmons are due, the Chazy limestone, the Black marble of the Isle La Motte, the Loraine shales, the Champlain group, the Ontario group, the Helderberg series, the Erie group, and finally the Taconic system; achievements which it was given to no one in America nor in Europe to attain.

During the same year, 1842, the final report of the third district, by L. Vanuxem, was published; and in this at p. 13, we have a tabular view identical with the one of Dr. Emmons, the only changes being the name Loraine shales, which is replaced by Hudson River group, the grey sandstone is removed from the Champlain division, into the Ontario division, the Onondaga salt group and the Manlius water-lime are put into the Helderberg series. Vanuxem takes special care to say, at pp. 12 and 22, that the names of Taconic, Champlain, Ontario, Erie and Helderberg have been given by Emmons, and that "the views of Dr. Emmons were cordially embraced and adopted with some modifications." The two other final reports of the first and fourth districts, were not issued until one year later, in 1843, and the first volume of palæontology in 1847. The dates and facts signalized by Emmons and Vanuxem fix beyond any possible doubt and discussion the priority of the classification and the leading part taken in it by Dr. Emmons. Vanuxem accepted and encouraged the adoption of the Taconic system, until his death in January, 1848.

The great value of Emmons' discoveries, classification and nomenclature, was shown at once by the very violent opposition with which certain geologists received them. It is always dangerous to be too far in advance of your contemporaries; and Dr. Emmons was quickly reminded that good and acute observations are not sufficient in the view of some young ambitious geologists, whose knowledge and power of observation are not equal to their desire of notoriety as great observers. His report of the second district of New York was attacked at once by Henry D. Rogers, in his "Address delivered at the meeting of the Association of American Geologists and Naturalists, held in Washington, May, 1844." New York, 1844, at pp. 16–19, who in substance says: that the so-called Taconic system was simply the Champlain system "disguised by some change of mineral type and by igneous

metamorphosis;" and from that date until the meeting of the Boston Society of Natural History, of October 17, 1860, when I made a joint communication with Barrande "On the primordial fauna and the Taconic system," the Taconic was considered as metamorphosed beds, "in the utmost confusion," of the Champlain, Upper Silurian, Devonian and even Carboniferous, by Messrs. H. D. Rogers, W. B. Rogers, Ed. Hitchcock, W. W. Mather, James Hall, W. E. Logan, and J. D. Dana.

Dr. Emmons' "Taconic system" of 1844 with its fossil descriptions and figures, instead of disarming his adversaries was received with an opposition which from that moment took a form of persecution, unique in the history of geology, even when compared with the not very creditable course taken by Murchison against Sedgwick. Having inserted in his first volume of "Agriculture of New York," as an "Introduction" necessary for the understanding of all the soils, a description of the Taconic and New York systems, with fine sections, beautiful geological views and fossils, Dr. Emmons prepared a geological map, "a reprint in the main of the map which accompanies the first reports," with the Taconic system colored and made a distinct part of the map. But the map was so obnoxious to some of the geological corps of the state of New York, that although it was described at p. 363 of the volume, and paid for by the state treasurer, it was suppressed and remained concealed until 1887. So Emmons did not see it even, and he died believing that the map had been destroyed by some unknown person.

I shall not speak of all the malicious acts to which poor Emmons was subjected by his opponents; I have sufficiently exposed some of them in my "American geological classification and nomenclature," Cambridge, 1888, and in several others of my papers published lately. I shall only say that: "During the discussion upon the Taconic system, when his views were opposed by some in a manner which certainly to say the least, was not fair, I never heard him express a word showing anger, or petulance toward his adversaries," as one member of his family writes to me. And when detailing to me himself the persecution he had been subjected to for scientific opinion, in his letter of the 28th of December, 1860, which I have published in part in "The Taconic system and its position in stratigraphic geology" (*Proceed. Amer. Acad. Arts and Sci.*, new series, vol. xii, p. 188, Cambridge), he

says: "I never treated Mr. James Hall unkindly in my life. I was the instrument who secured his appointment as palæontologist by governor Marcy." The ostracism to which Emmons was subjected—being in fact ruled out of American geologists—led him to "look upon the subject with a kind of indifference," as he says in his published letter to E. Billings, dated Raleigh. Feb. 5, 1861. ("Remarks on the Taconic Controversy," by E. Billings; *Canadian Naturalist*, April, 1872). Nevertheless, from 1855 to 1860, in his "American Geology" and "Manual of Geology," Dr. Emmons maintained sternly his views, his opinions and discoveries, continuing to give new facts, well observed, as well palæontologically as stratigraphically; and going so far as to identify the fauna he had found in his Taconic system with the primordial fauna of Bohemia, so well described by Barrande.

In 1856, a change took place in the curatorship of the State Cabinet of Natural History of New York, which was the beginning of the vindication of Dr. Emmons' opinions and discoveries. John Gebhard Jr., a very inefficient curator, who removed from the State collection, in obedience to "order given by Dr. Beck, on an *ex-parte* statement", the Taconic specimens of Dr. Emmons, and placed some of them in the Hudson River group, resigned and was replaced by colonel Ezekiel Jewett. At first, it seemed that one opponent of Emmons' had been replaced by another, and the first time that Dr. Emmons met the new curator in the Museum, he said: "I suppose that like the others you will not speak to me and recognize my position of state geologist," alluding to Gebhard and F. B. Meek, who both avoided Dr. Emmons each time he entered the Museum. But colonel Jewett was not a man to be long influenced by prejudice and unfounded accusations, and although influenced at first by his relation and friendship with the paleontologist of New York, he was determined to see for himself. Being an excellent collector of fossils and a good stratigraphist, he soon saw that there was something wrong about the so-called enormous Hudson River group, and the pretended Champlain metamorphosed beds of the Hudson river valley; and little by little, by his own observations in the field, and his better acquaintance with the methods of the two parties, he was led to become a strong adherent to the Taconic system and its author Dr. Emmons, to the detriment of the metamorphosed Champlain and enormous Hudson River group advocated by the state palæontologist. It took

him two years for the change, but after 1858, colonel Jewett became the strongest friend of Dr. Emmons, and in his blunt, fearless and military way of talking, he advocated the Taconic system and praised its author.

Unhappily colonel Jewett's principles were averse to publishing anything; but in his correspondence he took such strong ground in favor of the Taconic, sending specimens of the trilobites of Georgia to Billings, to Barrande and myself, that he contributed largely to call the attention of others to the great mistake made by the palæontologist of New York and by the Geological surveys of Pennsylvania, Vermont and Canada. From that moment, Dr. Emmons was no more alone to sustain his opinion.[1] There is no doubt that colonel Jewett's well known honesty influenced Barrande, de Verneuil, Billings, Agassiz, and myself in the right direction.

Finally, in 1860, came the "turning point" in favor of Dr. Emmons and the Taconic system. Until then Joachim Barrande had never seen Emmons' work, nor ever heard of his discoveries, except in a sort of distant echo as being untenable and erroneous; but as soon as he was in possession of Emmons' publications, he took his part and became the strongest opponent to the transfer of the primordial fauna above the second fauna as advocated by the palæontologist of the State of New York, and accepted and maintained boldly by the other opponents of Dr. Emmons.

Unfortunately, at that moment Dr. Emmons disappeared out of sight and reach in the great civil war. Having been state geologist of North Carolina since 1851, he left his house at Albany on the 2nd of September, 1860, never to return.

A few quotations from his letters and also from some of colonel Jewett, all addressed to me, will give in a few words, the true history of the results achieved by Dr. Emmons' supporters.

Having heard through colonel Jewett, that I had made a joint communication with Barrande before the Boston Society of Natural History, on the 17th of October, 1860, in favor of the

[1] Professor C. Dewey, the old teacher of Emmons always sustained the Taconic system; and a pupil of Emmons, professor R. P. Stevens, of Brooklyn, was also a constant supporter. But the death of Vanuxem and the retirement of Conrad were extremely unfortunate and left the field to those who concentrated and united their efforts to disseminate their erroneous views of metamorphic Champlain and of an immense Hudson River group.

Taconic system, he wrote me from Raleigh, North Carolina, the 20th of November: "I shall wait with anxiety the reception of your promised paper. You have already, so colonel Jewett tells me, stirred up the *trio*, Logan, Hall, and Hunt. The latter took the colonel to task a few days ago for his belief in the *Emmonsian myth*, as it is called by Mr. Lesley, of Philadelphia."

In a letter dated Raleigh, January 23, 1861, he says: "I am under the highest obligations to you for the decided part you have taken in the question respecting the Taconic system......Mr. Meek was afraid of making a call at my house lest Hall might hear of it. (Meek was assistant of Mr. J. Hall from 1852 to 1858, and during his long stay at Albany, he did not call once at Dr. Emmons' house, because when taken as an assistant by Mr. Hall, he agreed that he would have nothing to do with Emmons.) ....I always doubted Hall's ability to make out a thing, for I found he made many blunders—has made them all along the New York Survey, beginning say, with calling the Helderberg limestone *Mountain limestone*, etc., etc. He has with great zeal denounced me in his third volume of the Palæontology of New York, just out, and run his statements to prove the error of the Taconic system over forty pages, I am told." (The third volume of the Palæontology of New York was really published in November, 1860; several copies were already distributed when Barrande and Marcou's joint paper appeared the 24th of December, 1860, at Boston. In the *American Journal Sci.*, January, 1861, the editor announced that in "the Introduction Professor Hall handles with masterly skill the proper classification of the lower horizons of life in our planet and that a review of that important chapter with the views of Barrande will appear in the next number." But that review never appeared; the distribution of the official volume of palæontology was stopped and the few copies already distributed were returned to the author, and Mr. Hall suppressed all his statements designed to prove the error of the Taconic system, recast the whole of his Introduction, suppressing the forty pages denouncing Dr. Emmons, and after three years of hesitations and of consultations with Logan and his other associates, he finally distributed the volume in May, 1862, without giving one word of his so long announced "proper classification of the lower horizons of life in our planet" as he understood it before the publication of

that uncalled for, very troublesome joint paper of Barrande and Marcou.)

Poor Dr. Emmons was provoked in all sorts of ways, and treated with the greatest contempt. In his letter dated Raleigh, December 28, 1860, already published in part in my paper, "The Taconic system and its position in stratigraphic geology," p. 188, Cambridge, 1885, Emmons says: "In fine, the persecution I suffered for opinion has been rarely equalled. Rogers said, in a Section discussion of the Taconic system, that as for the Taconic system it is dead! dead! dead!!! with a significant pointing of his finger to myself; and yet, there never was a plainer case on the face of the earth."[1]

The following are extracts from some of the letters of the honest colonel Jewett:

Geological Rooms, Albany, January 10, 1861.

MY DEAR SIR:

On my return yesterday from a journey I found the pamphlets ("On the Primordial fauna and the Taconic system, by J. Barrande, with additional notes, by J. Marcou," Boston, December, 1860.) you were so kind as to send me and for which I beg you to accept my very sincere thanks.

I feel a great interest in the subject you have so well sustained, and I hope that the Taconic system, the most important part of our New York section, will no longer be ignored. Taking professor Hall's teaching without investigation, I taught others that the Potsdam sandstone

[1]Thirty-three years later the same spirit with, if possible, an aggravation of arrogance, inspired the writer of the paper entitled: "A brief history of Taconic ideas" (*Amer. Jr. Sc.*, vol. xxxvi, Dec. 1888; pp. 410–427), in which the Taconic system is declared again dead. A professor of geology, graduate of Yale College and consequently an old pupil of Mr. J. D. Dana, says in a letter to me, dated May 6, 1889: "When after saying for fifty years that a certain thing is dead and continuing to bury it during that period, the idea is carried to impartial spectators that the corpse is quite a lively affair to refuse to be buried. My attention was attracted to the Taconic question by the fact that, in spite of repeated interments, the Taconic system—like Banquo's ghost—would not stay quiet. I was further impressed with the unseemly warmth of the sextons who had so frequently officiated, and I was led to study the question in an entirely impartial spirit, and I have concluded that Dr. Emmons and yourself were and have been in the right."

The same year another writer attacked Dr. Emmons on every possible point; palæontology, stratigraphy, lithology, classification, use of the name Taconic, right of priority, as a collector of fossils, and even as to the disappearance of his geological map from the first volume of the *Agriculture of New York* ("The Taconic system of Emmons, and the use of the name Taconic in geologic nomenclature," by C. D. Walcott, *Amer. Jr. Sci.* vol. xxxv, March, April and May, 1888, pp. 229, 307 and 394.)

was the oldest sedimentary rock in the State, until I was obliged by ocular demonstration to acknowledge I was wrong, and as far as in my powér I have corrected the error; and of course I feel it my duty to assist professor Emmons to the extent of my ability; and I was delighted to learn he has more powerful and efficient friends.

I was pleased to learn your opinion that the Potsdam sandstone should be placed in the Taconic, for I have ever thought it belonged to the *Bottom rocks.*

.......I should be very happy to see you in this city and show you among other things the fossils collected from the Taconic system.

I am, dear sir, with great respect your obedient servant,

E. JEWETT.

Jules Marcou, Esq., Boston. Curator Nat. Hist.

Geological Rooms, Albany, January 23, 1861.

MY DEAR SIR:

Please accept my very sincere thanks for your kind letter and valued work on "Geology of the United States and the British provinces of North America," Boston, 1853, which came yesterday.

The "Geology of ......" I read carefully soon after it was published but was so stupid or unfortunate as to think it a work of great value and still continue in the opinion. I was not surprised that it was attacked by professor Hall—no work of the kind escapes him * * * But just now he has enough on his hands to sustain his false theory in relation to our rocks and he will find it a herculean labor to keep out of sight more than *three-fourths* of our sedimentary strata. I am told * * * that he *now* thinks more of stratigraphy and less of palæontology than before Sir William E. Logan published his letter! (Remarks on the fauna of the Quebec group of rocks and the Primordial zone of Canada addressed to Mr. Joachim Barrande," Montreal, 3rd January, 1861). He observed that if Sir William's account is true geology is all *afloat*. We shall probably see in the March number of the *Journal of Science* some fine special pleading. (A letter of Mr. Hall to the Editors, continues his opposition to the "scheme of Barrande in reference to the successive faunæ of trilobites, as established in Bohemia and the rest of Europe.")

I have little doubt but Emmons will cordially agree with you in relation to the Potsdam sandstone. I had a talk with him on the subject and the trilobites of Owen from it and now think his opinion agrees with mine. He is exceedingly obliged to you for the very efficient assistance you have rendered him. Emmons is a man of sterling worth and integrity and by having been placed in a wrong position by sharp practice and maneuvering in a lawsuit where he was only a witness, has been the *best abused* man in America, and all without cause. [It was in regard to a publication of a great Geological Tabular view for the schools of New York.]

Hall says that Sir William (Logan) has not endorsed the Taconic system: but as you observe he will be obliged to do so. His letter to Bar-

rande is rather crusty, and in bad grace, and no wonder, as he reviewed the ground in 1859. Then Hall was his palæontological dictator, as he has been through the whole survey, but he could not resist the overwhelming truths produced by Billings.

I am, my dear sir, very truly your friend,

E. Jewett.

J. Marcou Esq., Boston.

Geological Rooms, Albany, Oct. 17, 1861.

My Dear Professor:

I am highly gratified and obliged to you for your active assistance to dispel errors and do justice to science and to a most worthy man. * * * Mr. Billings speaks of you in the highest terms both personally aud as a man of science. We hear nothing from Emmons; he will feel grateful when he learns that you and Billings have devoted your talents to sustain him. I hope very soon to hear from him and will let you know at once.

I do not understand French well enough to write to Barrande, and I beg you to offer him my highest regards and thanks for his valuable assistance in exposing the errors of our palæontologist of the state of New York and doing justice to Emmons and his friends.

I am very truly your friend,

E. Jewett.

Professor Jules Marcou, Boston.

Geological Rooms, Albany, January 27, 1862.

My Dear Professor:

Many thanks for your most excellent paper on "the Taconic and Lower Silurian rocks of Vermont and Canada," November, 1861, Boston; nothing for years has given me more pleasure, for it fixes unalterably the long disputed facts. * * * Dr. Emmons will owe you and Billings great gratitude for your noble and generous assistance, and as I used all my efforts in his behalf * * * I offer you my most cordial and sincere thanks.

I do so want to communicate the news to our honest and good friend Emmons! but he is not to be corresponded with, and sealed up by the Rebellion. When he comes back had we not better get up an ovation for him to let mankind know his worth and merit? He is one of the most modest and unassuming men I ever saw. * * * Let me again thank you for the very efficient and lucid labor in the cause of science and truth. I am very truly your obliged and sincere friend,

E. Jewett.

Professor Jules Marcou, Boston.

In July, 1861, I received from Barrande a large bundle, containing thirty copies of his "Documents anciens et nouveaux sur la faune primordiale et le systéme Taconique en Amerique," twelve of which were addressed to Dr. Emmons. It was impossible to communicate with him and I sent the bundle to colonel Jewett, who

tried in 1862 and 1863 the sending in different small installments of only one copy each of Barrande's important memoir and my two papers of 1861 and 1862. As his wife succeeded in reaching him in 1863, it is probable that Dr. Emmons saw our three papers and that he was cognizant before going to his grave that Barrande had established beyond any doubt and forever, his claims as the discoverer of the Primordial fauna and the right of American geology to name the strata containing it "the Taconic system."

As I have said before, the masterly and extremely important memoir of Barrande, "is a model of clearness, of straightforward opinions on the Taconic system, as well stratigraphic as palæontologic, and the most honest protest ever published on any controverted geological question." ("Barrande and the Taconic System," by Jules Marcou, AMER. GEOLOGIST, February, 1889, p. 120.)

I cannot end better my exposition of Dr. Emmons' great achievement, than in translating the last paragraph of Barrande's chapter "Observations générales sur la faune Taconique," at p. 297 (*Loc. cit*) in which he says: "If the distinction of different local horizons in the primordial fauna is one day pointed out in North America—even without any regard to the present classification and nomenclature—the name *Taconic System* will not have re-echoed in vain in both hemispheres."

Good and great Barrande, his noble words will always remain and be quoted by all geologists, and the two names of Emmons and Barrande are attached forever to the oldest fossiliferous strata of our world. They are the discoverers and they are the classificators.

In order not to interrupt the exposition of Emmons' Taconic system and its special fauna first discovered by him, I have neglected to speak of his work in another field of geology; for his activity was not entirely confined to the oldest strata. Emmons was appointed state geologist for North Carolina in 1851, and commenced the work January, 1852. In November of the same year he presented his "First Annual Report," in which he described and referred to their right place the coal fields of North Carolina, classifying them as the equivalent of the *Letten-Kohl* (Triassic system) of Germany.

In 1856, Dr. Emmons published his "Geological Report of the Midland Counties of North Carolina," Raleigh and New York,

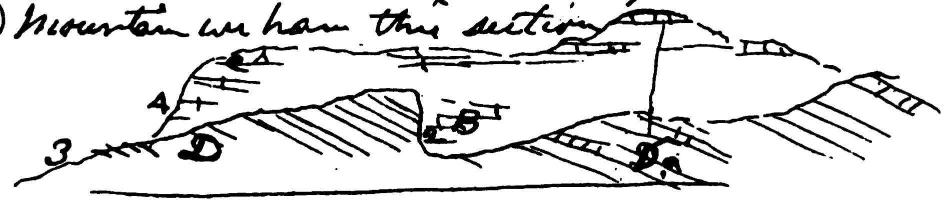
another work of the first order, on account of the excellent figures and descriptions of fossil plants of the Triassic types and of vertebrate remains. He completed the palæontological part of his North Carolina discoveries the following year in publishing his Part VI. of "American Geology," Albany, 1857, devoted entirely to fossil animals and plants of the Permian and Triassic systems of the Atlantic slope. In it, Emmons describes the oldest mammal yet found under the name *Dromatherium sylvestre.* All the drawings made by his son, E. Emmons Jr., are well executed, being accurate and far superior to all the figures of other fossil plants published until then and even since in North America. We can add that later publications on the same subject made by the U. S. Geological Survey are not superior in any respect, as well for the drawings as for the descriptions and determinations; and that Dr. Emmons' works on the Triassic flora of North Carolina remain the standard and authoritative publications on American palæophytology. Dr. Emmons also was very successful in his important and valuable reports on the agriculture of the states of New York and North Carolina, seven volumes of which were issued between 1846 and 1860.

The painful strain put upon him, a northern man and loyal to the Union, by the great civil war, was too much. In some of his letters to me, he says: "Our political institutions tremble. The South is really in hostile attitude to the North."...."The political condition under which we are living in the South is quite oppressive. I cannot but look with great fear upon the results of agitation, and it unfits me for work." Ill health soon confined Dr. Emmons to his plantation, Brunswick county, where he died on the 1st of October, 1863, surrounded by his wife and son. His remains were brought home and interred in the Albany Rural Cemetery. All his valuable papers, field notes, maps, books, etc., left in North Carolina after his death, in a supposed safe place, were lost and are probably destroyed.

The portrait given is from a small daguerreotype taken in the early time of the art, and is the only likeness of him.

The letter reproduced by photo-lithography is a fair example of his writing and signature. It was addressed to professor Jules Marcou, Chestnut street, Boston, Mass.

You are right in your view that the Taconic system had been much disturbed prior to the deposition of the Silurian. Thus at Bald Mountain we have this section



There are many illustrations of this kind, one at Troy.

A Chazy Limestone or Calciferous
B " " with abundance of Maclurea magna,
C " sordida
D. Da Taconic slates.
2. A precipice 30 feet high forming the western wall of an Ancient valley in which the limestone was deposited.
3 old outcrop of slate seen by Lyell & Hall. The limestones have been worked back to Da for lime.

Cutting through both slates & limestone for about 200 yds. - thereby exposing both rocks most perfectly - proving unconformability, & no folding under, according to Rogers -

PUBLICATIONS[1] OF DR. EBENEZER EMMONS.

1824.—A sketch of the geology and mineralogy of the western part of Massachusetts and a small part of the adjoining states, by Chester Dewey (*Amer. Jr. Sci.* vol. viii, pp. 1–60),—the first paper in which Dr. Emmons is quoted. Professor Dewey says: "Dr. E. Emmons, of Chester, from whom I have received many valuable remarks on the rocks," and also: "Most of the minerals of Middlefield and Chester have been discovered by Dr. E. Emmons, of Chester, an indefatigable and acute observer." From Dewey's paper we learn that Dr. Emmons read before the Lyceum of Natural History of the Berkshire Medical Institution a paper upon "The Minerals of Middlefield and Chester," and that professor Dewey made use of it for his catalogue of "single minerals," pp. 31–60 at the end of his memoir. As the Lyceum of Berkshire never published anything, very likely Dr. Emmons' first paper was never published in full, and all we know of it is through professor Dewey. In fact, Dr. Emmons collaborated to such an extent, for the observations and the geological map of the "sketch" of Dewey, that it may be said with justice that it is a joint paper of Dewey and Emmons.

1824.—Notice of the granitic veins and beds in Chester, Mass., by E. Emmons (*Amer. Jr. Sci.*, vol. viii, pp. 250–252).

1826.—Description of the Grevilleanum serratum, a new genus belonging to the order Musci, by Lewis C. Beck and E. Emmons (*Amer. Jr. Sci.*, vol. xi, p. 183).

1834.—Circulation in vegetables, by E. Emmons (*Amer. Jr. Sci.*, vol. xxvi, pp. 99–103).

1834.—Birds of spring, time of appearance in Williamstown, Mass., 1831–33, by E. Emmons (*Amer. Jr. Sci.*, vol. xxvi, p. 208).

1835.—Strontianite in the United States, by Ebenezer Emmons, with a note by C. U. Shepard (*Amer. Jr. Sci.*, vol. xxvii, pp. 182–183).

1836.—Notice of a scientific expedition to Nova Scotia, by Prof. E. Emmons (*Amer. Jr. Sci.* vol. xxx, pp. 330–354).

1837.—First Annual Report of the Second Geological District of the State of New York, by Prof. E. Emmons (*Communication from the Governor, relative to the Geological Survey of the State, to the Assembly.* Assem. No. 161, Albany, 1837, pp. 97–153).

1838.—Report of E. Emmons, Geologist of the Second Geological District of the State of New York (*Communication from the Governor, relative to the Geological Survey of the State, to the Assembly.* Assem. No. 200, Albany, February 20, 1838, pp. 185–252).

1839.—Third Annual Report of E. Emmons, of the Survey of the Second Geological District (*Communication from the Governor, relative to the Geological Survey of the State, to the Assembly.* Assem. No. 275, Albany, February 27, 1839, pp. 201–239. In the same paper—Assembly No. 275—there is a *Communication from Messrs. Em-*

[1] Captain A. W. Vogdes and professor Joseph F. James have aided me for the titles of papers by Dr. Emmons published in two periodicals: "The American Mag. and Repository" and "The American Quart. Jour. of Agriculture."

mons and Hall, relative to a place of deposit for the different specimens collected by the Geologists, pp. 5–7.)

1840.—Fourth Annual Report of E. Emmons, of the Survey of the Second Geological District (*Communication from the Governor, transmitting several reports relative to the Geological Survey of the State, to the Assembly*. Assembly No. 50, Albany, January 24, 1840, pp. 259–353).

1841.—Fifth Annual Report of Ebenezer Emmons, M. D., of the Survey of the Second Geological District (*Communication from the Governor, transmitting several reports relative to the Geological Survey of the State, to the Assembly*. Assembly No. 150, Albany, February 17, 1841, pp. 113–136).

1841.—Memoir of the Geological Survey of the state of Deleware: including the application of Geological observations to Agriculture. by James C. Booth, A. M.; a review by Prof. E. Emmons (*The American Mag. and Repository of useful literature; devoted to science, literature and art, and embellished with numerous engravings*. Edited by John S. Wood M. D. and Barnabus Wood, vol. i, pp. 77–79, Albany, Sept. 1841. Only two volumes of this rare publication were issued, for the year 1841–1842).

1841.—Geology of the Montmorenci, by Ebenizer (*Sic*) Emmons, D. M., with one woodcut. (*Amer. Mag. and Rep., etc.*, vol. i, pp. 146–150, Albany, November, 1841. Reprinted in THE AMERICAN GEOLOGIST, August, 1888, vol. ii, pp. 94–100, Minneapolis.)

1841.—Utility of Natural History (extract from a lecture delivered in the Albany Medical college), by E. Emmons, M. D., Prof. Nat. Hist. etc. (*Amer. Mag. and Rep. etc.*, vol. i, pp. 163–165; Albany, December, 1841).

1842.—Geological Observations by Ebenizer (*Sic*) Emmons M. D. (*Amer. Mag. and Rep. etc.*, vol. ii, pp. 5–9, Albany, January, 1842).

Dr. Emmons says: "In the November number of this magazine I gave a brief account of the rocks at the falls of Montmorency." In this number he gives some additional remarks in relation to those rocks more particularly on their lithological characters, their extent and the changes in position since their deposition and the period when those changes took place, under the sub-head, I. Lithological characters. II. Extent. III. Dislocation and changes of position. IV. Period or era of those dislocations, with two woodcuts.

1842.—Geology of New York, Part II, comprising the Survey of the Second Geological District, by Ebenezer Emmons, M. D., Professor of Natural History in Williams College, pp. 437, fifteen plates, 4to, Albany.

1842.—Topography, Geology, and Mineral resources of the State of New York, by E. Emmons (*A Gazetteer of the State of New York;* Albany, J. Disturnell, editor, March, 1842, pp. 5–25. Reprinted in part by A. W. Vogdes in THE AMERICAN GEOLOGIST, vol. ii, pp. 352–355, November, 1888, Minneapolis).

1842.—Resolutions on the subject of Drift, by Prof. Emmons (*Reports*

of the First, Second, and Third Meetings of the Association of American Geologists and Naturalists, at Boston, in 1842, p. 60. Boston, 1843).

1843.—Metamorphic changes by artificial heat, in Potsdam sandstone, by Prof. E. Emmons (*Amer. Jr. Sci.*, vol. xlv, p. 146).

1843.—Rain-marks in the Potsdam sandstone, by Dr. Emmons (*Amer. Jr. Sci.*, vol. xlv, p. 316).

1844.—The Taconic system; based on observations in New York, Massachusetts, Maine, Vermont, and Rhode Island: by Ebenezer Emmons, M. D., Professor of Natural History in the Albany Medical College. Albany, pp. 68, six plates, 4to.

1845.—*The American Quarterly Journal of Agriculture and Science*, conducted by Dr. E. Emmons and A. J. Prime, vol. i, Albany, 1845, contains the following geological articles by Emmons: 1. Beds of oyster shells on the Hudson river, pp. 215–219; 2. Phosphate of lime and other fertilizers in the older rocks, pp. 219-221.

1846.—Agriculture of New York, by Ebenezer Emmons, 5 vols. and plates, Albany, 1846–1854, 4to.

Chapter V of the first volume, "the Taconic system," and Chapter VI, "the New York system," contain the best and most important classification and description of the strata of the state of New York, pp. 45–204. At p. 361 of the first volume is the "Description of the Geological map," which was never distributed with the volume, because the map was concealed until 1887.

1846.—*The American Quarterly Journal of Agriculture and Science*, conducted by Dr. E. Emmons and A. J. Prime, vol. ii. Albany. 1846, contains: 1. Drift and changes in the position of soils, by E. Emmons, pp. 26–33; 2. On the supposed Zeuglodon cetoides of Prof. Owen, by E. Emmons, pp. 59–63; 3. Agricultural geology, by E. Emmons, pp. 1–15 and pp. 180–198.

Vol. III, conducted by E. Emmons and A. Osborn, Albany, 1846, contains: 1. Agricultural geology of Onondaga county, by E. Emmons, pp. 161–192; 2. Structure of Granite Mountains, by E. Emmons, pp. 207–210; 3. Description of some of the bones of the Zeuglodon cetoides of Prof. Owen, by E. Emmons, pp. 223-231, one plate.

Vol. IV, conducted by Dr. E. Emmons, A. Osborn and O. C. Gardener, New York, 1846, contains: 1. Some of the mineral resources of New York, by E. Emmons, pp. 27–50; 2. Mineral and agriculture resources of New York, pp. 199–202; 3. Remarks on the Taconic system, containing in part the discussion upon this subject at the meeting of the Association of American Geologists and Naturalists, September, 1846, pp. 202–209; 4. *Conularia vèrneuili* n. sp. Emmons, 2 figures, p. 330.

1847.—*The American Quarterly Journal of Agriculture and Science*, conducted by Dr. E. Emmons and A. Osborn, vol. v, Albany, 1847, contains: 1. The limestones and lime, pp. 65–113; 2. No coal in the New York rocks, pp. 125–129; 3. Reply to Prof. Adams' remark on

the Taconic system in the Association of American Geologists and Naturalists, at the Boston's meeting of 1847, by Dr. Emmons, p. 212; 4. Report from Mr. Vanuxem, on the Taconic system to show that they are rocks intermediate between the primary rocks and the Potsdam sandstone; and Mr. S. S. Haldeman read a report showing that *Atops trilineatus* and *Triarthrus beckii* were not identical; p. 213. (The report of Vanuxem was never published, but Haldeman's report was published by Dr. Emmons at pp. 194–195 of vol. v, *Amer. Quart. Jr. Agriculture and Sc.*)

1848.—On the identity of the *Atops trilineatus* and the *Thriarthrus beckii* (Green), with remarks upon the *Elliptocephalus asaphoides*, by Professor E. Emmons (*American Association Advancement of Science*, vol. i, first meeting held at Philadelphia, September, 1848, pp. 16–19, Philadelphia, 1849).

1851.—On Aliments, by Professor E. Emmons (*American Association Advancement of Science*, fifth meeting, held at Cincinnati, May, 1851, pp. 90–91, Washington City, 1851).

1851.—Remarks upon unconformability, by Prof. Emmons (*American Association Advancement of Science*, sixth meeting, held at Albany, August, 1851, p. 256, Washington City, 1852).

1851.—Remarks on the origin of stratification, by Dr. Emmons (*American Association Advancement of Science*, sixth meeting, held at Albany, August, 1851, p. 299, Washington City, 1852).

1852.—Report of Professor Emmons, on his geological survey of North Carolina. His first Annual Report. Executive Document, No. 13, Raleigh, November 22, 1852, pp. 182.

1855.—American geology, by Ebenezer Emmons, vol. i, Part I, Albany, 1855, pp. 194 and one plate.

1856.—Geological Report of the Midland Counties of North Carolina, by Ebenezer Emmons, New York and Raleigh, October 1, 1856; pp. 352 and 13 plates.

1857.—American geology, by Ebenezer Emmons, Part VI, Albany, 1857; pp. 152 and 12 plates.

1857.—Fossils of the sandstones and slates of North Carolina, by E. Emmons (*Amer. Assoc. Adv. Science*, eleventh meeting, held at Montreal, August, 1857; pp. 76–80, Cambridge, 1858).

1858.—American geology, by Ebenezer Emmons, Part II, Albany, 1858, pp. 251 and 19 plates.

1858.—The chemical constitution of certain members of the Chatham series in the valley of Deep river, North Carolina, by Dr. E. Emmons (*Amer. Assoc. Adv. Science*, twelfth meeting, held at Baltimore May, 1858; pp. 230–232, Cambridge, 1859).

1859.—Manual of Geology, by Ebenezer Emmons, pp. 297, New York, 1859. A second edition, with additional notes at pp. 280–281, was issued in 1860.

1859.—Remarks on the head of Clepsysaurus found in Chatham county, North Carolina, by Prof. Emmons (*Proceed. Acad. Nat. Sciences, 1859*, p. 151, Philadelphia).

1859.—The Dromatherium sylvestre, Emmons, from the coal of Chatham county, North Carolina; and remarks on the debituminization of coal, by Prof. Emmons (*Proceed. Acad. Nat. Sciences, 1859*, p. 162, Philadelphia).

1860.—Agriculture of North Carolina, Part II; by Ebenezer Emmons, Raleigh, March 1, 1860, pp. 112.

1860.—North Carolina Geological Survey, Part II, Agriculture, by Ebenezer Emmons, State Geologist, Raleigh, May, 1860, pp. 95.

1872.—Mr. E. Billings has published a letter of Emmons' addressed to him, in his paper: "Remarks on the Taconic controversy," p. 13 (*Canadian Naturalist*, April, 1872).

1880.—Mr. J. Marcou has published a letter of Emmons addressed to him, in his paper: "Sur les colonies dans les roches Taconiques des bords du lac Champlain," pp. 19–20 (*Bull. Soc. geologique France*, vol. ix, November, 1880).

1885.—Mr. J. Marcou has published eight letters of Emmons addressed to him, in his paper: "The Taconic system and its position in stratigraphic geology," pp. 184–191 (*Proceed. Amer. Acad. Arts and Sciences*, new series, vol. xii, December, 1884, Cambridge).

Post-scriptum.—Although thirty years have elapsed since Dr. Emmons left Albany for North Carolina, never to return alive, and it is twenty-seven years since his death, the opposition to his discoveries and views has kept the character of disingenuousness, and covert persecution to his adherents shown from the beginning, forty-five years ago.

Finding it impossible to deny any longer the priority of his discoveries, the aim of his opponents has taken the round-about way of denying the exactness of his observations, the correctness of his determinations and descriptions of fossils, as well for the primordial rocks and fossils, as for the Trias of North Carolina. It is not that the number of his adversaries has increased; on the contrary it has remained stationary, while the number of adherents to Emmons' views has increased ten-fold from what they were in 1863, notwithstanding the death of Emmons, Barrande, Billings, and Jewett. But the same spirit of lowering the national record of American geology, and of throwing dust into the eyes of those who cannot see and judge for themselves in the field, of the value of arguments put forward, has continued to this day its unworthy work.

The number of original and well trained observers is still too limited on this continent, and the ground to cover is too great. So it is still relatively an easy task—although not so easy as it was in 1846—to make such combinations of unscrupulous geolo-

gists as to obstruct and delay the general acceptance of the great work of Emmons.

After the intervention of Barrande in favor of Dr. Emmons, all his critics were at sea, swimming in every direction to escape from their untenable position of the transfer of the primordial fauna above the second: but at the same time taking good care to ignore all the observations of Emmons and his friends. However, all their efforts at classification have continued to be most helplessly incorrect; they have oscillated from one error to another, and they have done nothing during the last thirty years but to nullify all the time what they have proposed themselves, changing year after year their curious classifications and nomenclatures. All their creation of great faults—such as in the rear of the citadel of Quebec, in front of the citadel, in the bed of the St. Lawrence river, at Wolfe's cove (called a *profound* fault), east of forts Nos. 2 and 3 (called an overlapping fault), at Cape Rouge, St. Foix, Quebec city, island of Orleans, Montmorency Falls, Washington county, New York; Georgia, Vermont, etc.; their creation of great and continuous synclinal and anticlinal axes; their creation of fosiliferous limestone-conglomerate with Calciferous fossils in the matrix and Lower Taconic fossils in the pebbles at Pointe Lévis, which are not at all conglomerates; their creation of equivalency and synchronism of strata, such as Pointe Lévis, Phillipsburgh, Fort Cassin and Shoreham groups identified with the normal and typical Calciferous of the geological survey of New York: the citadel hill of Quebec identified with the Trenton of Montmorency falls: the Taconic slates of Emmons eastward of Albany, composed of 5,000 feet of strata without the true Lorraine fauna and containing a supra-primordial fauna, identified with the 1,000 feet of the typical Lorraine shales, etc.; all such creations and empirical explanations are mere expedients. Being unable to agree among themselves on anything acceptable without suppositions absolutely baseless, they are reduced to call to their help British classificators and British palæontologists, who ignored the primordial fauna and all the true stratigraphial sequence of the Lower palæozoic rocks, until Barrande went to their islands, in 1850, to point them out.

But passionate men, as well in geology as in any other human pursuit do not see the true character of their position, and it is useless to expect a reasonable surrender of mistakes unequalled

and unique in the history of geology which class those who made them at a very low level as observers. They have enjoyed and still enjoy to a certain extent popularity, however mistaken they are in their observations and classifications, and they do not intend to resign it. It is reserved to future generations of American geologists to render justice and honor to the memories of those who have suffered during all their lives for progress and truth.

Cambridge, Mass., April. 1890.

ON THE CHEYENNE SANDSTONE AND THE NEOCOMIAN SHALES OF KANSAS.

BY F. W. CRAGIN, Topeka, Kansas.

(Continued from October Number).

In portions of the Kansas counties of Kiowa, Comanche, Clarke, Meade, Ford, Pratt, Barber, Harper, Kingman, McPherson, and Rice, and overlying the Cheyenne sandstone wherever the latter occurs, may be seen remnants of a geological stage which is of especial interest; first, because it is one which was discovered in Indian Territory, and announced as found there, thirty-five years ago, by Prof. Jules Marcou, but which, as an American formation, has been ignored by the rank and file of American geologists from that day nearly to this; and again, because its American geography, stratigraphy, and palæontology are still very imperfectly known.

This is the Neocomian. It includes, in the southern Kansas district, a series of marine shales, with subordinate sandstones, shell-conglomerates, and shell breccias, situated between the base of the Dakota and the summit of the Cheyenne sandstone. Over a large part of this district, owing to erosion of one or both of the latter formations, the Neocomian rests upon the Triassic or is overlaid directly by the Tertiary. Its shales are usually light drab or buff in the upper portion, and of a dark slate color in the lower. The most conspicuous feature of its outcrop is the horizon of dark slate-colored shale. The color of this horizon has led to much useless prospecting for coal. Lignite, indeed, often occurs in it in seams, fragments, and pockets, but is nowhere found of such quality and quantity as to be practically available as a fuel.

Its outcrop in Kansas is mostly linear and very irregular. Beginning on northern tributaries of the Medicine Lodge river in the northwestern part of Barber county, it extends up the valley of that river to points on the headwaters a few miles north and west of Belvidere; thence to the west, in an irregular southeasterly directed loop, to a point in the bed of Bluff creek, Clark county, a few miles above Vanhem; and thence southwest to a point on Crooked creek, Meade county, near Odee. West of these points, it passes beneath the upland. It reappears in the Public Land between the Cimarron and the North Fork of the Canadian in the region where these streams most closely approach each other. This and some limited occurrences in the divide between the Red Fork and the Cimarron, south of Avilla, connect it with the Canadian and Washita river district in which it was first recognized in its true relations in 1853 by Prof. Marcou.

Of the two divisions into which the American Neocomian can be more or less distinctly separated in Texas, only the older, the Fredericksburg of Prof. Hill, is present in Kansas. The actual contact of the Dakota series upon the Fredericksburg division is well shown near the heads of Bear creek and the Little Sandy, in Clark county, and of the Medicine Lodge river and several of its branches in Kiowa county; the latter district locally yielding characteristic Dakota leaves in abundance. It is less perfectly shown by the contact of remnants of a Dakota ledge entombed in Loup Fork calcareous sandstone at the point where the trail from Dodge City to Camp Supply descends from the divide north of Ashland. At the Blue Cut hill, S. S. W. of Belvidere, in Kiowa county, and on many high points in this and neighboring counties, boulder-remnants of the Dakota sandstone overlie the Fredericksburg shales and usually bear incrustations which unmistakably indicate their release from the Loup Fork calcareous sandstone. We have thus clear evidence of the former deposition of Dakota sediments upon those of Fredericksburg age over this region and of their subsequent removal from most of it by erosion. At the West Bear creek locality, in Clark county the superimposed Dakota shows a thickness of not less than fifty feet; on the Middle Branch of the Medicine Lodge, it has a thickness of not less than seventy.

The thickness of the Neocomian series in Kansas is variable, but probably nowhere exceeds 150 feet. This maximum is ap-

parently reached in Kiowa county, south of the Medicine river. In the high bluffs of Bluff creek, below Vanhem, it measures nearly as much. At many localities it ranges between 60 and 100 feet. North and east of the Medicine river it becomes thinner. In portions of Kingman, Harper, Barber, Comanche and Clark counties, the Neocomian has been entirely eroded from areas where its former presence is attested by numerous specimens of *Gryphæa pitcheri* and a small *Gryphæa* which is perhaps distinct from the latter and fragments of characteristic shell-breccia. North of Sharon both of these forms of *Gryphæa* are included abundantly in the Loup Fork conglomerate, together with shell-breccia and fragments from the Cheyenne and Triassic sandstones, showing the working over of the Mesozoic rocks by the Tertiary lake waters.

The dip of the Neocomian series, as a whole, like that of the Cheyenne Sandstone, is eastward and southward. Individual strata are subject to considerable undulation, and may dip for a short distance in any direction.

In Kansas, the Fredericksburg shales rest everywhere upon the Cheyenne sandstone or upon the Triassic red-beds, with the possible (but, I think, improbable) exception of one or two localities in McPherson and adjoining counties, where the absence of Cheyenne sediments from beneath a part of the Fredericksburg may, at some point, bring the latter directly upon the Permian shales and limestone.

The sections given below will afford an adequate idea of the prevailing character and local variation of the Neocomian of southern Kansas, and of its relations to older and more recent formations:

BELVIDERE SECTION.

No.	Approx. Thickness in feet.	Description.
Top of hill.		(This horizon overlaid in neighboring hights with Tertiary conglomerate.)
1	25—30	Light olive-brown or yellowish-brown earthy shale, with numerous layers of glossy, purple-red *Ostrea franklini* breccia, in which large specimens of *Gryphæa pitcheri* are imbedded.
2	40—50	Same as No. 1 (from which it is elsewhere not separable, and here not sharply so), but with additional thin layers of brown-yellowish calcareous sandstone, which are in part barren, in part charged with valves of two or three small undetermined species of bivalve mollusks, and sometimes with *Ostrea franklini*.

BELVIDERE SECTION.—Continued.

No.	Approx. Thickness in feet.	Description.
3	35—40	Shales similar to those of Nos. 1 and 2, but becoming darker below and thus imperceptibly grading into the upper part of those of No. 4; intercalated throughout with bands of hard, arenaceous, yellow limestone; the latter usually charged heavily with molluscan-shells, among which, *Cyprimeria crassa*, *Cardium kansasense*, *Ostrea franklini*, *Turritella marnochii*, var. *belviderei*, and an *Anchura* allied to *A. ruida* are the most abundant.
4	15—20	Dark, slate-colored, carbonaceous shale, weathering into scale-like chips, with occasional yellow and brown streaks, often impregnated with sulphuric acid and charged with beautiful radiate and rhomboidal selenite crystals, with occasional bands of dark, arenaceous limestone (sometimes compact sandstone) containing fossils apparently identical with some in No. 3 and thin bands of lignite.
5	.5—1	A gray shell-conglomerate composed mostly of molluscan—in part, of other invertebrate—fossils of many species. *Gryphæa* vars., *Exogyra flabellata*, *Trigonia emoryi*, *Idonearca vulgaris*, *Cardium belviderei*, *Cyprimeria gradata*, *Turritella marnochii*, *Ammonites acuto-carinatus*, *A. pedernalis*, and a *Serpula*, like *S. intrica*, are some of the more abundant forms.
6	20—40	The Cheyenne sandstone.—Obliquely laminated, mostly incoherent sandstone, commonly grey, or grey and yellow, but often gorgeously decorated with crimson, purple, scarlet, orange, yellow, brown and other colors. Sometimes impregnated with sulphur (chiefly in the upper part), which often incrusts its exposures with a yellow "blossom." It contains fragments and bands of lignite, and silicified cycads and conifers.
7		Fine, soft, brick-red sandstone, marlstone, and shale, forming here the summit of the pre-Cretaceous "red-beds," and of supposed Triassic age.

Besides the more characteristic species above noted, the following are the forms thus far found in No. 3 of the Belvidere Section: *Gryphæa pitcheri** Mort., same, var. *forniculata* White, *Neithea quinquecostata* Sby., (?) *Plicatula arenaria* Mk., *Inoceramus* sp., *Limopsis* sp., (?) *Nucula* sp., *Remomdia ferrissii* Cragin, *Trigonia emoryi* Con., *Cardium* sp. (quite distinct from the abundant *C. kansasense* (Mk.,) *Cyprina ovata* M. & H., *Pholadomya* (?) *elegans*, (?) *Mactra* sp., (?) *Globiconcha elevata* Shum., *Neritina* sp., *Turritella marcochii* White (typical), *Ammonites acuto-carinatus*, and a number of forms of undetermined genera.

Similarly in No. 5, occur the following forms, in addition to those above given: *Ostrea diluviana* L., *Anomia tellinoides* Mort., *A. argentaria* Mort., *Neithea quinquecostata* Sby., *Pinna* sp., *Gervillea* sp. (allied to *G. anceps* Desh.), *Modiola burlingtonensis* Whitf., *Limopsis* sp., *Idonearca* (?) *tippana* Con., *Cardium*

*Of this species two specimens before me differ in no respect, save in their more triangular outline, from the analogous *G. couloni* of the European Neocomian.

hillanum Sby., (?) *Gouldia** sp., *Pholadomya sancta-sabæ* Roem., *Liopistha protexta* Con., *Homomya alta* Roem., *Scalaria* sp., (?) *Lithotrochus* sp., and several other genera not yet satisfactorily determined. No. 5 has also yielded a specimen of coral of the family *Astræidæ*, and several casts of large sigmoid burrows (lenzitoid in cross-section), supposed to be those of a Nereid worm.

The *Cardium* designated in No. 5 as *C. belviderei* is allied (*fide* Marcou) to the Neocomian *C. cornuelianum* D'Orb.

BLUE CUT MOUND SECTION.

No.	Approx. Thickness in Feet.	Description.
Top of hill.		On and about the summit of the mound are scattered a few fragments of Loup Fork calcareous sandstone and numerous boulders (the largest 5—8 ft. long) of dark-brown Dakota sandstone.
1	20	Upper part with boulders of Dakota sandstone; lower part with debris of brown-and-purple-banded, often hollow, concretions of clay-ironstone, associated with yellow clay-shale. No fossils detected.
2	20	Greenish-yellow clay-shale with plates of light, yellowish-brown to rust-colored sandstone having clay-ironstone concretion-roughened faces; both clay and stone containing very large *Gryphæa pitcheri*. *Ostrea franklini* also appears sparingly in the lower part.
3	25	Olive-grey or olive-brown to yellow or buff earthy clay-shales with numerous thin strata of *Ostrea franklini* breccia, containing some mostly rather large specimens of *Gryphæa pitcheri*. (Supposed equivalent of No. 1 of the Belvidere Section.)
4	10—15	Forming upper third of the east face of the "Blue Cut." Similar to No. 3 lithologically, but graduating below into the dark shale of No. 5.
5	25—30	Lower two-thirds of east face of "Blue Cut." Dark slate-colored or bluish-black shales with bands of shell-conglomerate, the shale containing, in the lower part most abundantly: *Cyprimeria crassa*, *Turritella marnochii*, var., *belviderei*, *Cardium*, *kansasense*, *Leptosolen belviderei*, *Ammonites belviderei*, *Ammonites acuto-carinatus*, *Exogyra flabellata*, *Gryphæa pitcheri*, and *Ostrea franklini*,—the latter, with some *Gr. pitcheri* and an occasional *Exog. flabellata*, making up several stony layers of shell-conglomerate three to ten inches in thickness.

Most characteristic of No. 5 are several small forms of *Gryphæa* ranging from an inch to an inch and a half in hight. One of the commonest of these, save for the characteristic sulcus seen on the posterior slope, bears striking resemblance to the Jurassic *G. arcuata* (*incurva*). This feature, however, belongs especially to *G. pitcheri*. Such a combination of characters in one variety perhaps points to the origin of the latter species from

*The interior features of this very common shell are obscured in the specimens thus far collected. Prof. Marcou thinks it an *Astarte*.

a small gryphæan, the American analogue of the former. Another prominent variety has the beak much less produced and the umbonal slope radiately grooved or striated.

No. 5 yields also a species of Polyzoan and vertebræ of a plesiosaurid.

The *Gryphæa* of the lower part of No. 2 of this section are of remarkable size, ranging from three to four inches in hight, and, at a locality nearly a mile east of the Blue Cut, equally large ones occur at the same horizon. One of the latter reaches a hight of four and three-eighths inches; it is of the typical triangular form.

Nos. 4 and 6 of the Belvidere section, followed up the Medicine Lodge river and Otter creek, can be traced to within about a furlong of the Blue Cut,* where they pass beneath the level of the Otter creek valley, the horizon of the sandstone probably passing under the Blue Cut at a depth of between thirty and forty feet below the floor of the cut.

On the north slope of a ravine which skirts the Blue Cut mound, and but a few rods distant from the latter, occur, in yellow shales, laminæ of yellowish grey sandstone, or arenaceous limestone, containing numerous small, rostrate, entire-margined bivalves of undetermined genus, with occasional specimens of *Cardium kansasense*, *Cyprimeria crassa*, and a rather large species of *Inoceramus*. Of these forms, the first characterizes No. 2; the three latter, No. 3 of the Belvidere Section. In its lithology and in the state of preservation of its fossils, this horizon resembles No. 2 of the Belvidere Section. It probably represents a passage-horizon between Nos. 3 and 2 of the Belvidere Section. It has not been detected in the Blue Cut Mound section proper, where, if present, it is probably to be found in No. 4, the fossils of which are still unexamined.

The above-mentioned contact of the Dakota upon the Neocomian is shown in the following section of the bluffs near the head of West Bear creek in Clark county:

*The "Blue Cut" is on the line of the C. K. & W. Railway, a few miles S. S. W. of Belvidere. The Belvidere Section includes a ravine and a hill at the top of the same, half a mile to a mile nearly due south of Belvidere.

UPPER WEST BEAR CREEK SECTION.

No.	Approx. Thickness in feet.	Description.
1		Loup Fork Tertiary calcareous conglomerate.
2	40	Dark brown to yellowish Dakota sandstone, containing meagre fragments of dicotyledonous leaves.
3	20–30	Grayish white clay, interstratified with horizontal and oblique beds of soft yellowish brown sandstone, varying to arenaceous clay more or less abundantly charged with clay-ironstone concretions, the latter locally so abundant that nearly the entire thickness of the horizon becomes one compact and massive ledge of clay-ironstone concretions. Fragments of *G. pitcheri* in the basal portion, which is, in fact, a transition to No. 4, are the only traces of fossils.
4	75–90	Blue and yellowish gray or brownish shale (the upper 20 or 30 feet usually yellowish or olive gray and the lower part blue, but the blue color often prevailing nearly or quite to the upper limit), with selenite crystals and thin plates of arenaceous shaly limestone in which (chiefly in the upper part of the series) occur *Gryphæa pitcheri*, *Gryphæa vesicularis* Lam., *Trigonia emoryi*, *Ostrea franklini*, *Pholadomya sancta-sabæ*' *Cardium hillanum*, *C. kansasense* *Idonearca vulgaris*, and species of *Anomia*, *Inoceramus*, *Cyprimeria*, etc., too obscure for specific identification.

I have not been able to separate No. 4 of this section into distinct palæontologic horizons. Here, as elsewhere, the lowest and darkest portion of the dark horizon is void of fossils or nearly so.

The prevailing pattern of the *Gryphæa pitcheri* of this locality is different from that of the Belvidere and Blue Cut mound districts. In that of the latter localities the tendency in the outline of the larger number of specimens is toward an isosceles triangle; in that of the Bear creek specimens what may be called the "bowl" of the valve tends to a circular outline, from which the umbonal region is prominently produced. Specimens somewhat approaching this type occur also on the upper part of Thompson creek in Kiowa county. Of *Gryphæa vesicularis*, I have collected one typical specimen only. This specimen, from near the top of No. 4 of the West Bear creek section, seems specifically identical with that figured by Prof. Whitfield in Monograph IX of the U. S. Geological Survey (Pl. IV, Fig. 1), and still more closely agrees with the form illustrated in Fig. 1, Plate IV of Marcou's Geology of North America under the name *Gryphæa dilatata*, var. *tucumcarii*. Certain forms of *Gryphæa* occurring on Bear creek lead me to suspect that it would be possible to collect a series of forms connecting *pitcheri* with *vesicularis*. The *Ostrea franklini* of this locality is chiefly of a large and thick variety, offering marked contrast to the thin and fragile

form that prevails in Kiowa county. The Bear creek *Inoceramus* is identical with that seen at Belvidere, and near the Blue Cut. The absence of *Turritella* here (complete, so far as yet observed) is noticeable.

On Bluff creek, also in Clark county,* we again find the Neocomian well developed. Passing down the valley, we first meet with it in the bed of the creek not far below the old (Peter Henderson) crossing of the Camp Supply trail. It is here overlaid with Tertiary; but at the Thomas ranch, three miles further up the creek, occurs a limited outcrop of soft, gray to yellow and red sandstone, which is probably a ledge of the Dakota. The outcrop below the Camp Supply trail is largely blanketed by the sand and gravel of the channel. It consists of slabs of blue laminated sandstone, associated with blue and yellow clay mud (the latter evidently water-soaked shale) and containing obscure fossils, among which I have recognized *Gryphaea pitcheri*, *Trigonia emoryi*, *Idonearca vulgaris*, *Cardium hillanum*, and obscure forms supposed to be *Cardium kansasense*, *Cyprimeria*, *Mactra*, a radiately ribbed *Ostrea*, and a large areolated Polyzoan. Immediately below Vanhem occurs a ledge of shell-breccia of *Ostrea franklini*, *Gr. pitcheri*, etc.

Half a mile lower down the creek occurs a forty or fifty foot bluff of Neocomian shale (of the usual olive-gray to yellowish color in the upper part), with arenaceous laminæ in some of which *Ostrea franklini* so abounds as to form a breccia, while others, less crowded with fossils, contain this form together with *Gr. pitcheri*, *Tr. emoryi*, *Card. hillanum*, *Cyprimeria*, etc. Other laminæ consist of cone-in-cone having curious, circular, shallow, funnel-shaped depressions, concentrically ribbed with reversed imbrications. The funnels commonly vary from an inch to four or five inches across, and are, perhaps, a fourth as deep; some have raised borders of uniform width and are of remarkable symmetry. Cone-in-cone is, in general, a common structure in the shales of the Kansas Neocomian.

Some three miles below Vanhem the bluffs form a large amphitheatre, the east bluff rising 200 feet above the creek-bed with

*For important facilities afforded me by Henry Fares, Esq., of Fares' Ranch, in aid of my geological reconnaissance of Clark county, I would here make grateful acknowledgment.

great abruptness, and offering, at the southern end, the following section :

BLUFF CREEK SECTION.

No.	Approx. Thickness in Feet.	Description.
1		Lake Marl slope.
2	50	Loup Fork calcareous concretionary grit, with remains of *Mastodon, Aphelops, Hipparion*, etc.
3	40	Neocomian shales, light olive brown to yellowish gray in the upper third of its thickness (which is also more or less arenaceous), becoming gradually bluish or dark slate-colored below. Fossils mostly of the commoner Neocomian sorts—not separated into faunal horizons.
4	8–10	Soiled grayish brown sandstone, of soft earthy texture, with slight admixture of dark earth or shale. No fossils observed.
5	75—90	Dark (olive-brown to blue-black) Neocomian shales, nearly barren of recognizable fossils, and based on the Triassic Red-beds.

A portion of No. 4 of the Bluff Creek section, at the lower end of the "amphitheatre," is cut off from the main stratum and stands as a rapidly-wasting pinnacle. This, and certain features of the outcrop of the stratum in the bluff itself, remind one of the Cheyenne Sandstone, and the occurrence of such a stratum so far above the base of the series indicates a partial return to the physico-geographic conditions under which the Cheyenne sandstone was formed.

At a point a few miles below the "amphitheatre" on Bluff creek, and about a mile above the entrance of Hackberry creek, the base of the Cretaceous is marked by a shell-bed which has close lithological resemblance to No. 5 of the Belvidere section, but is more or less colored by material incorporated from the Red-beds. The prevailing fossils in this shell-bed are *Trigonia emoryi* and *Ostrea diluviana*, the stratum being a breccia chiefly of the former shell, with an arenaceous matrix, and occasional specimens of *Exogyra flabellata, Idonearca vulgaris*, etc. Fifty to seventy-five feet above this shell-bed and separated from it by a slope, there outcrops a second arenaceous gray shell-rock, in which the fossils are very obscure, but whose lithologic resemblance to Belvidere 5 is perfect, and which yields the large sigmoid worm-burrow of the latter. Its horizon is apparently close to that of the unfossiliferous stratum of earthy sandstone seen in the Bluff creek "amphitheatre" (No. 4 of section).

The occurrence here of two strata lithologically and palæontologically like Belvidere 5, one basal, the other median in the series, and the association of the latter with a sandstone not unlike the Cheyenne, gives some color to the supposition that whatever be its palæontologic relation to the upper Jurassic, the Cheyenne sandstone should at least be considered *stratigraphically* a member of the lower Cretaceous. Indeed, at the point of disappearance of the Cheyenne stratum near the Blue Cut, may be seen indications of a change in the character of the stratum, as if it were a premonition of a giving place of the sandstone to shale, by which latter the sandstone is at other places more or less invaded.

Of the county of Comanche, the Neocomian series is best developed in the northeastern part, where it resembles that of the adjoining part of Kiowa county, both lithologically and in the abundance of *Cyprimeria crassa*, *Turritella*, and associate fossils of the Belvidere Section. The horizon of the small *Gryphæa* combining features of *G. pitcheri* with those of *G. arcuata* (No. 5 Belvidere Section), also appears here between the Cheyenne sandstone and the black shale; but the fossils are often poorly preserved,. by reason of the excess of sulphur, iron, and gypsum. The black hill south of Avilla, which I have crossed, I have never found time to examine; but I have casually observed *Gryphæa pitcheri*, *Ostrea franklini*, *Cyprimeria crassa*, etc., as among its fossils. The wide separation of this hill from other outcrops, and the numerous loose specimens of *Gryphæa* scattered about to the west and to the northeast of Avilla, taken in connection with the outcrops on Elk and Mule creeks, testify to the former existence of the Neocomian series over the entire county, and to its subsequent extensive erosion.

Loose *Gryphæa* and *Exogyra* also occur in the western parts of Harper and Kingman counties.

It was, till recently, supposed that the Neocomian formation did not occur north of, nor indeed quite to, the Arkansas river. In my "Geological Notes on the Region South of the Great Bend of the Arkansas," (*Bul.* 9. p. 37, Feb. 1889) I announced the discovery of a supposed Comanche outcrop on the west line of McPherson county. This locality has been insufficiently examined, but is characterized by yellow to blue-gray shales with layers of *Ostrea franklini* breccia and other stony layers in which *Car-*

dium kansasense occurs, together with *Turritella marnochii*, var. *belviderei*, and a species of *Neritina* (apparently identical with that from Belvidere), and one of *Dentalium*. With others of the normal form, occur frequent specimens of the *Turritella*, in which the apical region is remarkably produced and attenuated. Bands of red and yellow ochre occur here. One or two similar outcrops occur in the east part of Rice county.

I have used the older name, "Neocomian," in preference to the later one, "Comanche," throughout in this article because, as it seems to me, there is no member of the American Cretaceous which is so clearly referable to a European chronologic equivalent as the series of shales here passed in review. The name "Cheyenne sandstone," herein applied to Belvidere 6, is used merely as a temporary convenience. It is quite likely to become, when the palæontologic and stratigraphic relations of No. 6 are better known, a synonym of "Trinity Sandstone," as the latter will perhaps become "Potomac" and that, at length, "Wealden" or "Purbeck."

EXPLORATIONS IN ALASKA.

[The scientific expedition sent out last spring, under the joint auspices of the National Geographic Society and the United States Geological Survey, for the purpose of exploring the region about Mount St. Elias, Alaska, has returned. Mr. Russell, who organized the expedition and had charge of the work, is now in Washington. The party consisted of Israel C. Russell, geologist; Mark B. Kerr. topographer, both members of the Geological Survey; E. F. Hosmer, general assistant, and seven camp hands, hired at Seattle, Wash., of whom J. H. Christie was foreman. Owing to uncertain health Mr. Hosmer returned home from the first camp.]

All arrangements for camping in an unknown country were completed at Seattle early in June, and on the 17th the expedition sailed for Sitka on the steamer Queen, one of the excursion boats plying regularly between Puget sound and South-Alaska. The voyage to Sitka furnished an opportunity for seeing the fine glaciers of Taku inlet and Glacier bay, thus serving as an introduction to the still more wonderful icefields about mount St. Elias. On arriving at Sitka the members of the expedition were transferred at once to the U. S. S. Pinta, under the command of Capt. Farenholt, who had previously received instructions from the Secretary of the Navy to take them to Yakutat bay.

The Pinta reached the mouth of Yakutat bay on June 25. The

bay is a broad, deep inlet extending more than thirty miles inland, and it was the plan of the expedition to begin work near its head on the west shore. The weather being thick, Capt. Farenholt did not think it advisable to take the vessel up the bay, and the voyage had to be made by means of boats and canoes in a driving rain storm. The actual base of operations was reached on June 28, and the studying of the geology and geography of the region began at once.

"When the storm passed away," says Mr. Russell, "we found ourselves on a wild shore, encumbered by icebergs and at the immediate base of a majestic mountain range, trending southeast and northwest. Along the southern base of the mountains there is a plateau some thirty miles broad, divided by the waters of Yakutat bay. Our task was to explore and map the country from the bay to St. Elias, and as far beyond as practicable. Excursions were begun at once to the neighboring mountains and glaciers, and up Yakutat bay as far as the floating ice would allow a canoe to travel.

"One of these excursions took us to an island at the head of the bay, which we named Grand View island. From its summit, which rises boldly a thousand feet above the water, a magnificent view was obtained of a vast stretch of snow-clad mountains, from which glaciers of great magnitude descended to the sea, and ended in cliffs of ice several hundred feet high. From these the icebergs crowding the bay were derived. One of these glaciers we named Dalton, the pioneer explorer of the region; another of larger size at the head of the bay was named Gardner Hubbard, from the president of the National Geographic Society. A magnificent mountain peak rising some 10,000 feet immediately above the Hubbard glacier received the same name. Another towering peak on the same mountain crest, triangular in shape, and always of purest white, was named mount Seattle, in acknowledgement of the faithful services of our camp hands, whose homes are mostly in the 'Queen City of the Sound.'

"While glacial and geological studies were being pushed forward, Mr. Kerr measured a base line with considerable accuracy, and began a map of the region. From the ends of the base-line sights were taken to several peaks and hill-tops near at hand, the angles between the lines of sight and the base-line affording data for the determining of other distances. By means of angles of

elevation, their hights could also be calculated. The stations whose position and elevation had thus been determined were made the extremities of new base-lines, from which sights to all the mountains in the region could be made, and the hights of the highest peaks accurately determined.

"In addition to the 'dip angles,' the hights of the stations occupied were determined by means of a mercurial barometer. To aid in this work a 'base barometer' was read three times a day during July and August by Rev. Carl J. Hendrickson, who had charged of a mission at Yakutat. From this beginning the work of mapping the country was carried forward until the peaks to be seen from our line of march were located and their hights determined. Sketches and photographs were taken from many points of view; these, together with the triangulation, will furnish material for an accurate map of the region visited. The map will embrace upwards of a thousand square miles.

"As soon as topographic work was well under way a line of march towards St. Elias was decided upon. All of our rations, bedding, tents, etc., had to be carried, or 'packed,' by the men, the character of the country not allowing the use of animals. At first the trips from camp to camp had to be repeated several times. Profiting by experience we abandoned everything that was not essential, and as our work progressed we found that many things deemed indispensable at first could be left behind. Our line of march was toward the northwest, with the triangular summit of St. Elias as our guide. Fortune favored us in many ways. We found passes in the mountains leading in the direction we wished to travel and no insurmountable difficulties in the way, although great patience and judgment were required in treading the network of crevasses in the ice fields. Probably more than nine-tenths of our journey was across glaciers and snow fields.

"On the first of August we were midway between Yakutat bay and St. Elias, but still at the base of the mountains. Our camp was in the last and highest grove of trees that it was practicable to reach. The timber line is there about 1,500 feet high, and all trees disappear a few miles to the west. An island of rock, surrounded by vast glaciers, but clothed with beautiful flowers, rank ferns, and dense spruce trees, furnished a delightful spot for our base camp. We named this lovely oasis in the desert of ice

'Blossom island.' From there our work in the high mountains began.

"On following up Marvin glacier, which flows to the west of Blossom island, for about fifteen miles we reached an elevation of 4,000 feet and found an easy pass, although filled with glacial ice, leading westward across what, from a distance, seemed an impassable mountain range. We named this 'Pinnacle pass' on account of the tapering spires overlooking it. West of Pinnacle pass we descended to a glacier that has its source far to the north of mount Cook, and separates that mountain from the St. Elias range. On crossing this glacier and approaching the mountain wall which rises to the west of it, we again found a pass leading toward St. Elias that afforded an easy passage to the Conrad glacier, one branch of which rises on the northern slope of the great mountain. Following up this branch we at last, after twenty days' hard work above the snow line, found ourself encamped at the base of St. Elias. The weather had been clear for ten days and we had every prospect of a good day's climb on the morrow.

"Rising at 3 o'clock in the morning, we began what we believed to be the final ascent, but, after a few hours, storm clouds settled down around us, snow began to fall, and all landmarks were lost to view. The storm continued for thirty hours without cessation, and it was with difficulty that we found our way through the blinding snow to a lower camp where the necessary rations were to be had. A second attempt was made to reach the summit two days later, but another snow storm broke over the mountains as suddenly as the first. This time I was alone in the highest camp, where I was imprisoned for six days before being able to rejoin my party below, while Mr. Kerr was similarly isolated at the first camp lower down. When I started down there was six feet of new snow which refused to harden, and rendered it impossible to do more work among the high peaks.

"On descending to a lower level I started on an excursion up the glacier between St. Elias range and mount Cook, which gave promise of leading to a low pass across the main range, but a third snow storm coming on I was obliged to return to Blossom island, and there rejoined Mr. Kerr, who had descended a few days previous. My stay above the snow line lasted thirty-five days. During that time we lived in tents, many times camping

on the open glacier so as to be out of the reach of avalanches. All our cooking was done by means of small coal oil stoves.

"After returning to Blossom island, an excursion was made far out on the great Piedmont glacier, which forms a plateau about 1,500 feet high, stretching along the southern base of the St Elias range. This glacier is of the continental type in distinction from the Alpine glaciers, and has an area by estimate of about 1,000 square miles. It is the largest glacier known in the Northern hemisphere, with the exception of the icefields of Greenland.

"We returned to Yakutat bay about the 20th of September, having had stormy weather almost all the time since leaving the vicinity of St. Elias. On the 22d of September our hearts were gladdened by seeing the Corwin steaming up the bay. Capt. C. L. Hooper, commander of the Corwin, acting on his own judgment, and knowing that we would have a hard time if left at Yakutat until winter set in, made the cruise from Sitka especially for our relief, and conveyed the expedition to Port Townsend, where we arrived on October 2.

"From the point of view of the scientist, if not the Alpinist, our expedition was a success. The plan proposed before starting was carried out almost to the letter so far as the study of glaciers, geology, and topography was concerned, but we did not reach the top of mount St. Elias. The measurements made have determined that all the mountains in this region are lower than was previously supposed, and that St. Elias, instead of being the highest point in North America, is in reality a second-rate mountain. Its elevation, instead of being 19,500 feet, as previously considered, is about 15,000. Mount Cook has an elevation of 12,000, and Vancouver 9,400. Many other peaks in the same region are as elevated as Cook and Vancouver, but St. Elias is higher than any of its immediate neighbors. St. Elias is not an ancient volcano, as its form might suggest and has been reported by sea captains, who state that they have seen it in eruption, but is formed of sedimentary rocks. The great pyramid is really the end of a roof-like ridge in which the rocks dip northeast. Its form is typical of a large number of lesser mountains in the same region.

"The more important glaciers and mountains in the region explored were named principally in remembrance of distinguished American geologists who are no longer living. One grand moun-

tain, some thirty miles northeast of St. Elias, and apparently only second to it in hight, was named in honor of Sir William Logan, formerly director of the geological survey of Canada. Several lofty spires, to the east of Mt. Logan, were named after the vessels of the Navy and the Revenue Marine that have become celebrated for their voyages in Behring sea and the Arctic ocean.

"The results of the expedition will be presented to the National Geographic Society, and, as soon after as practicable, will be published by the society in the *National Geographic Magazine.*"

PRELIMINARY NOTES ON THE GEOLOGY OF CENTRAL NEBRASKA.

FRANCIS W. RUSSELL, Lincoln.

It was the writer's pleasure in 1888, to make a trip to the head waters of the Middle and North Loup rivers in Nebraska. Much of the country adjacent to these rivers being geological *terra incognita*, it was with no little feeling of animation that the investigation was begun. Previous, careful explorations along these streams had distinctly located the "Loup Fork beds," but it seems that study has not been directed to any later formations that might possibly exist.

The researches of Cope, Marsh and Leidy have shown that the Tertiary lakes in Nebraska were frequented by great herds of mammals, that gave a truly oriental aspect to the region. The existence of Miocene or Pliocene strata along these streams is a well established fact. Let us consider what may be the age of certain later beds as they are found in Sherman county, Nebraska. The solution of the problem in this county will serve as a key for the entire state.

The beds here lie along the Middle Loup river. In the first place a great similarity of appearance will be noted. Over a large area there is great homogeneity in composition. By virtue of the marked resemblance in appearance these beds might appropriately be called Loessian or Loess-like. At sight one can hardly distinguish between them and the typical Loess of eastern Nebraska. Chemical analysis, however, beaker elutriation and the use of the microscope reveal some important differences.

The deposit itself is buffish varying to drabbish. Occasionally there will be a small area having a yellowish cast. The appear-

ance of the hills is another criterion for distinguishing these beds. The bluffs are more angular than where there is a preponderance of sand. The contours are more pronounced and greater. Vertical and steep scarps will be found. This is not true of sand hills, excepting in a "blow-out" near their summits. This Loess-like soil is rich. Its vegetation is characterized by an absence of cacti, prickly pears, and soap weeds. The grass is even and not in bunches. The valleys are not closed, *i. e.*, not valleys of wind erosion. Sometimes, and indeed not infrequently, the sides of the hills are precipitous and not clothed with grass. The same cannot be said of sand hills although the vegetation upon the latter may be very scanty. No one, I think, will experience any difficulty in recognizing the formation.

The individual particles, entering into the composition of the beds under discussion, are quite uniform in size. This uniformity is pronounced in material taken from different localities. In general the particles are larger than those given by Messrs. Chamberlin and Salisbury in their report upon the Loess. In an examination of some 28,000 particles, I find the following results: Less than .014^{mm}, 24,000. Between .014 and .028^{mm}, about 4,000. A very few were over .028^{mm}. In the sixth annual report U. S. Geol. Survey at page 279, Messrs. Chamberlin and Salisbury give for Loess, of 150,000 particles, 97½ per cent. under .005^{mm}. It will be seen from the foregoing that the particles from central Nebraska range perceptibly higher in size.

In connection with this microscopic examination, the fact was noted that much of the material was water worn. The grains were rounded and smoothed. That much had been removed by attrition was evident. This fact registers another difference between this formation and the Loess.

The chief element entering into the composition is quartz. There are also present hornblende, biotite, mica, glauconite, orthoclase, and many grains stained with peroxide of iron. In addition to these from some horizons volcanic dust is found. When the last named element is present it is always in sharp angular fragments. It is also isotropic and no difficulty will be encountered in its detection. Excepting this volcanic dust one would be impressed by the regularity with which the other minerals are found, even from widely separated localities.

This formation is rich in calcium-carbonate; not only is the car-

bonate found in nodules, but it is desseminated throughout the mass. A quantity of the soil, freed from any nodules that might be therein, treated with hydrochloric acid shows the characteristic effervescence. A little barium hydrate makes one sure that the gas is CO_2. The frequently occurring calcium nodules are generally oval, but are sometimes lenticular in shape. As in the Loess many of these nodules seem to have been formed by the decay of bulb-like roots; calcium-carbonate replacing the matter of the root. Indeed, not uncommonly may we observe a specimen in which there has not been complete change. In such an instance part of the nodule will plainly be calcium-carbonate while the other part still retains its fibrous character.

Calcium-carbonate may be seen in threads or filaments penetrating the ground. Generally these threads are nearly vertical. It would seem that to this phenomenon the vertical cleavage of these beds may be ascribed. At least this is one factor that must be taken into consideration. A cliff once perpendicular manifests a tendency to retain its shape. These perpendicular, or approximately perpendicular, lime filaments seem to be the result of two causes. First the solubility in water of the carbonate of lime. By water it was distributed throughout the soil following the capillary tubes. The passage of the calcareous waters in these tubes would result in an approximately vertical deposition. This accounts partially for the roughness so often seen in the filaments themselves. In the second place the decay of rootlets and their replacement by lime may be the cause of the filaments that penetrate the soil in a more nearly horizontal direction. These filaments determine cleavage much as mica does schistosity.

The fossils of this formation show a striking similarity to those of the Loess. Indeed, a group of typical Loess fossils placed side by side with those from the upper beds of the Loup river region, would be distinguished from them with difficulty. The species are identical. The characteristic creamy appearance of *bona fide* Loess fossils is present. The most common forms are: *Succinea avara; S. lineata; S. verrilli; Zonites limatulus; Helix striatella; Pupa blandi; Vallonia pulchella; Helicodiscus lineatus; Helicina occulta; Carychium exiguum.* From these it will be seen that it is impossible to draw a sharp line of demarkation between the formation under discussion and typical Loess, on a basis of paleontological evidence.

On the Burlington and Missouri railroad in a cut some six miles east from Loup City, there is proof that there is nonconformity between certain of these beds that we are studying. At the base of the cut there is a stratum of red clay. This stratum contains a few small pebbles differing from the country rock. Immediately capping the clay there is a forest bed about 14 inches in thickness. The soil of this forest bed is a dark arenaceous loam. Heated in a porcelain crucible the dark loam becomes drabbish. There are no fossils in these lower strata. The forest bed rests unconformably upon the clay. Between the forest bed and the superimposed Loess-like formation there is marked unconformity. At the very base of this last formation are found the common and characteristic fossils before mentioned. A diagrammatic cross-section would exhibit about this result.

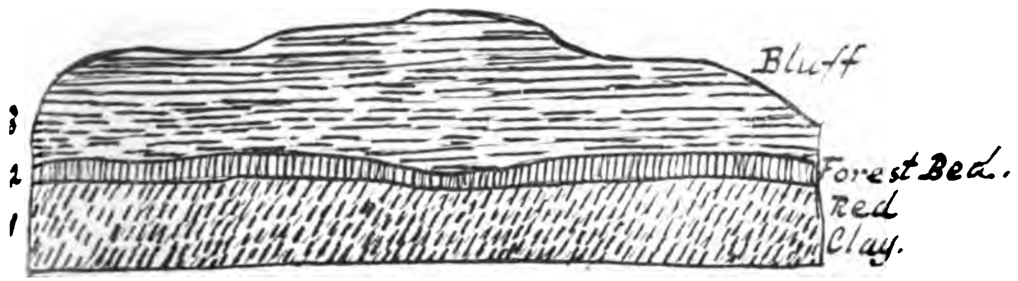


FIG. 1.

This nonconformity clearly shows that erosion was in action after the deposition of each stratum. The eroded surfaces of the red clay support the forest bed. Upon the latter, finally, came this Loess-like material. As already noticed there is absence of life in strata 1 and 2, and presence of life in stratum 3.

On the Middle Loup river, near Bœlus, in Howard county, the same nonconformity is again found. In this outcrop the forest bed is wanting and the bluff or Loess-like formation reposes directly upon and unconformably with the clay. In the clay stratum of the Bœlus section there are many small pebbles, principally quartzite, chert, diorite and diabase. As in the preceding section, the clay stratum is nonfossiliferous. In the upper or Loess-like formation the common and previously named species occur in abundance.

The clays have much the appearance of glacial clays. The en-

closed pebbles are clearly of a foreign character. I have examined the ground all the way from the place of deposition to the head of the rivers and I find no trace of these rocks *in situ.* This is upon the Middle Loup. Upon the North Loup there is more gravel than upon the Middle. Eight miles north of Ord at the mouth of Gravel creek there is a heavy deposit of gravel and sand. This deposit is quite extensive and has a maximum thickness of 20 to 25 feet. Chert and silicified wood are very abundant. At Almeria upon the North Loup there is an important gravel deposit. Its extent and thickness are less than the one previously mentioned. In all these gravels of Valley and Sherman counties, there is a resemblance. The mineral species are nearly the same.

Two questions at once arise. Are these gravels and clays synchronous? What is the age of the deposits? As yet I see no clear answer. It is a favorable circumstance that these beds are quite general in extent. Undoubtedly some place will be found where a correlation can be made. As to the age the conviction is firm in the writer's mind that future investigation will enable them to be checked with horizons of known age. These are the lines that future study must follow.

Passing from Sherman into Greely county another unconformity is observed. The strata here are not the clays, gravels, and Loess-like material as in the preceding instance. They are on the contrary strata of unquestioned Tertiary age and the Loess-like formation. This particular unconformity is well worthy a careful study. Upon the western bank of the North Loup river and near the town of Scotia there is an outcrop of white, chalky limestone. In places this limestone is almost pure calcium-carbonate. Again it contains impurities, as silica and magnesia; the magnesian ingredient manifesting itself as dolomite. Chert indicates the presence of silica. The entire outcrop has a thickness of some 80 feet. The eastern face of the scarp is washed by the North Loup river. Above and back the limestone is covered by the Loess-like formation.

The fossils from the chalk-bluffs are not abundant. However, *Planorbis*, *Physa*, *Limnœa* and *Viviparus* were generically determined. Aside from these several small *Lamillibranchs* were found, but their identification was impossible. The *Planorbis* occurs in such numbers as to render many of the broken faces of

the stone pitted from casts. Many diatoms occur, the most common being *Navicula sphærosphora*, *Cymbella lanceolata*, *C. cistula*, *Epithemia gibba*, *Encyoneme gracile*. In the superimposed Loess-like formation will be found *Succinea*, *Pupa*, *Helix*, etc.

As one approaches the base of the chalk formation a decrease in the abundance of fossils is noted. At the same time the rock becomes more heavily bedded. The increase of silica and magnesia is at once apparent. Near the top of the outcrop the rock becomes very chalky and shaly. Fragments of the stone are enclosed in the superincumbent material like boulders in the glacial clay.

Owing to the favors of the Burlington and Missouri railroad I was permitted to visit a similar exposure at Seneca, in Hooker county. Indeed, I may say that owing to these favors I have been enabled to make a much more satisfactory study of this region than would otherwise have been the case. The outcrop at Seneca presents no point of difference from the outcrop at Scotia. Near the top of the Seneca Tertiary limestone, I found the well preserved femur, tibia and some vertebræ of *Equus excelsus*. Also a tooth showing some resemblances to *Procannelus*.

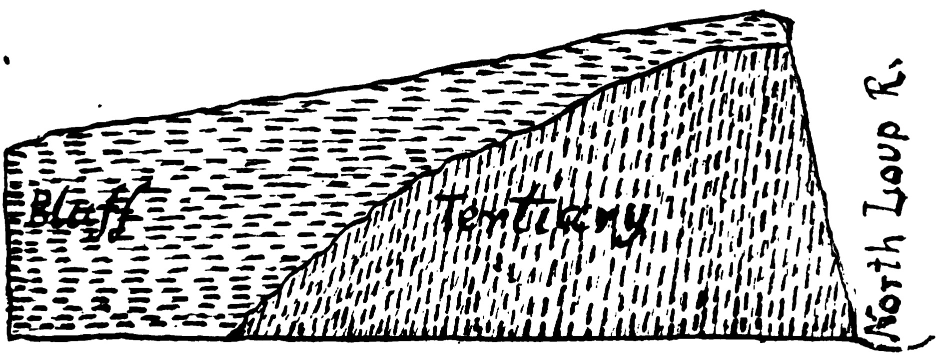


FIG. 2

These limestone outcrops seem to be Tertiary buttes, criteria by which we are enabled to measure the amount of erosion in this region. Standing as huge pinnacles, from them we can conceive the amount of removed Tertiary material. They are valuable leaves in the geology of Nebraska. The buttes conclusively prove that subsequent to the deposition of the beds of which they are the remnants there was a long period of erosion. Finally upon the worn

and jagged surfaces the bluff or Loess-like formation was laid down. These buttes tell more than the amount of erosion to which the land has been subjected. They register the volume of material removed by the rivers.

We shall expect to find pronounced unconformity between this Tertiary limestone and the superincumbent formation. We shall not be disappointed. The foregoing diagrammatic section, fig. 2, will aid in presenting this nonsequence of deposition.

As before stated the conclusion is evident that subsequent to the deposition of this Tertiary material there was pronounced erosion. During this time much was removed from the exposed surfaces. At a later time unconformably upon this the bluff or Loess-like formation was laid down. To mark this great erosion only isolated buttes remain. But these are enough. They convey more strongly than words the record of geologic history in Nebraska. In conclusion I may say that here is a fertile field for investigation. The limestone buttes afford a good datum plane. What then is the age of the later material?

Geological Laboratory, University of Nebraska.

GEOLOGICAL TESTS APPLIED TO ARCHÆOLOGICAL RELICS.

STEPHEN D. PEET, Mendon, Ill.

At the last meeting of the A. A. A. S. held at Indianapolis, a paper on the subject of "Paleolithics" was read by Mr. W. H. Holmes, and afterwards discussed by different members of section "H." This discussion seems to have excited considerable attention, and the daily papers commented upon it in their way. They give the idea that the distinction between "paleolithics" and "neolithics" has been abandoned. It may be well to state that so far as certain archæologists in America are concerned, this position which Mr. Holmes has taken, and which seems to have so surprised the public, is by no means a new one, though it has been maintained with considerable modesty, being an open question. While we acknowledge that there was a classification of the relics among the French archæologists which would put so called "paleolithic" relics in one class, and the "neolithics" in

another, yet on comparing the two it seemed to be impossible to draw the dividing line. We always found that whenever the inquiry was pressed, and the archæologists of that school were asked to give us tests by which we could classify the relics, we were referred to the "general appearance" and no definite test was given. The patina on the paleolithics was, to be sure, at times pointed out, especially if there was a black look to the patina, as this was supposed to be a sure indication of age, but the shapes were never definitely described; in fact the shape of the paleolithics, so called, especially those from France, could always be duplicated from the neolithics in America, the chelleen axes having their counterparts in the Tennessee relics, and the mousterien scrapers and spear-points finding their correlatives in the relics taken from the ash-pits of the Madisonville cemetery in Ohio, the solutreen, leaf-shaped implements having their correlatives in relics picked up on the shores of the lakes of Wisconsin, and the banks of the rivers in all parts of the country, and the madelenien harpoons having their correlatives among the implements so common in the northwest coast. This marked resemblance between the relics of the two continents might be explained, and was hypothetically explained, by the supposition of a rise and decline in the stone age, but this was not satisfactory. The later Indians were really in the paleolithic stage, and the earlier mound-builders in the neolithic. At length the subject had become so embarassing that there was a necessity in the case. This necessity was met by abandoning the point. The distinction between the paleolithics and the neolithics cannot be drawn by any hard and fast line. We have not, at least, in America, the marks of age in the relics which will enable us to class the two separately. We are in reality thrown over into the province of geology; if we are to ascertain what relics belong to the paleolithic and what to the neolithic we must first determine their geological horizon, this being the only criterion by which we can yet judge of their age. This is the position which the writer has held for a long time. The only question which he would now ask of the geologists aside from those points which they are best qualified to speak about, is this: Are we always sure that a relic which seemed to have been chipped by human hands is in reality a paleolithic relic, even if it is in the so-called paleolithic horizon? May not these apparent chippings be the result of accidental fractures, coming from

natural causes? Here we call upon the mineralogists to decide what material will be most likely to receive accidental fractures of a conchoidal shape which will resemble artificial chippings. The quartz relics found at Little Falls, in Minnesota, have never satisfied certain archæologists; they were not sufficiently marked in their artificial qualities to be selected as typical specimens. The argillaceous relics are not altogether satisfactory, as there is such a great variety in their shapes. Many of the chert specimens seem so extremely rude that it is a question whether they are artificial or not.

We would not, however, confine the subject to the fracture relics. According to some neolithic specimens of an advanced type are found, ante-dating, geologically speaking, all the paleolithic specimens. Statuettes, *finished in the round*, such as the nampa image, being found beneath the lava beds, and various steatite ollas, or mortars, in the auriferous gravels, etc. Under the circumstances would it not be well for the geologists to look for water-worn neolithic axes and hammers, with ground edges, and grooves, in the loess and in the moraine gravels? We do not say that such finds are likely to occur, but since the barriers have given way between the two classes, we would like to cover the whole field, and not reject a relic which seems to belong to the polished stone age, even if it should appear in unnatural surroundings. It may be a thankless task, for every relic of this kind has been challenged. Doubts will linger for many years to come. The problem of man's advent upon the stage is one which geologists and naturalists must help to solve, for archæologists are inclined to admit that their science when unaided by other departments, will not at present furnish the tests by which we may determine the age of a relic. We are inclined to say the same thing also in reference to what might be called "the remains," especially human crania. This is an unsettled, unsolved problem. The shape of a skull may to some minds be a proof of its age, but to other minds it is no criterion at all. For this, too, we are dependent upon the geologists to settle the question of age. The horizon which the geologists may recognize is the main test.

A LOCAL DEPOSIT OF CHESTER SANDSTONE.

By J. M. NICKLES, Sparta, Ill.

Chester, Illinois, is the locality of the typical exposure of the Chester group. A section of the bluff from the court-house to the Mississippi river is as follows :

No. 1.	Soil and sandstone, not exposed	73	feet.
" 2.	Limestone,	1	"
" 3.	Green, blue and purple marl,	12	"
" 4.	Limestone, regularly bedded,	7	"
" 5.	Limestone, irregularly bedded,	42	"
" 6.	Green and purple fissile shale and marl with thin bands of limestone,	53	"
" 7.	Limestone with occasional partings of green and blue shale,	82	"
		270	"

Several hundred yards northwest of the court-house occurs a local deposit about twelve feet in thickness in the bluff, of soft, yellowish homogeneous stratified sandstone, overlying conformably the lowest limestone of the preceding section. The deposit covers, perhaps, three acres. Its extent may be greater, but no evidence was found to warrant assigning it a larger area. The rock has been opened for about one hundred feet in longitudinal extent and is quarried for doorsills, window caps, and similar purposes, working very easily. Northwest of the sandstone is a ravine intersecting the bluff, at whose bottom is a small stream flowing into the Mississippi river. The other side of the ravine shows no evidence of the sandstone deposit, though the sandstone may be there covered up by drift and soil. On the south side of the ravine the sandstone may be traced for a short distance up the ravine, and then disappears under the drift.

Prof. A. H. Worthen, in the Geology of Illinois, vol. i, p. 285, comments on this sandstone, instancing it as an example of the variability of the Chester beds. After giving a section of the bluff, similar to that above, but differing in the thickness assigned to some of the beds, he states that the bed of green and blue shales is quite variable in character, especially towards the base ; that not more than a hundred yards above the point where he made his section, there is a bed of sandstone, replacing the

shale immediately above the lower limestone. In just what sense he intended the term "replacing" to be understood, I am in doubt. How did this sandstone replace the shale? They both lie conformably upon the limestone and apparently pass into one another. The line of junction is obscured by debris and overgrowing vegetation. The sandstone is overlaid by blue and green shales—No. 6 of the section.

At first glance it might be supposed that a fault had caused one of the lower sandstones of the Chester group to be brought up beside the shale. But faults, while common enough in the Chester group in western Kentucky, are rare in Illinois. Besides the underlying limestones can be traced continuously. The sandstones could not have been a slip on an extensive scale of the upper sandstone, as the green and blue shale overlying it is part of the thick bed of shale (No. 6 of section), which, from the abundance in it of the bryozoan *Lyropora*, may be termed the Lyropora beds. The latter fact also forbids the view that the sandstone is of more recent date, Tertiary or later.

In view of the facts given above, the following explanation is suggested. Where the sandstone now is, shale was deposited just as in the territory joining. After some dozen or fifteen feet had been deposited, some change occurred in the Chester seas by which a swift current scooped out the soft shaly material at this point. Presently the strength of the current diminished and an eddy was formed in which fine sand was deposited rapidly. After about twelve feet of this had been deposited, there was a return of the former conditions and shale was again laid down as before. To substantiate this explanation further observations are necessary.

THE GEOLOGICAL WORK OF MOSSES AND ALGÆ.

By Walter Harvey Weed, Washington, D. C.

The part that low vegetable organisms play in providing chemical change is of interest to geologists since it often results in the formation of deposits that have considerable geological importance.

The secretion of carbon and of carbonate of lime by plants and by animals is a familiar phenomenon, and constitutes the subject of very important chapters in chemical geology; but while much

stress has been laid upon the geological work performed by animals, particularly the molluscs and corals, the magnitude and importance of a similiar work performed by the humble members of the vegetable kingdom have not been fully appreciated.

It is with the hope of emphasizing the importance or this geological work of plants, by alluding to such facts as are already known, and describing several new features of the work, that the present paper has been prepared.

So far as known, the mineral-producing plants are all moisture-loving or aquatic species and belong to the mosses and the algæ, the only exceptions being a few lime-incrusted species of higher orders.

According as the mineral matter is abstracted by physiological processes, to build up the plant structure, or is a strictly chemical deposit resulting from reactions engendered by the growth and activity of the plants, the deposits may be direct, or indirect in their origin: By far the greater number of the deposits now known belong to the former class and in this case whether the beds are formed of stony masses of plant structures in situ, or result from an aggregation of isolated plant forms, it is the chemical work performed by the vegetation in the abstraction and segregation of mineral matter, to which geological interest attaches.

Besides the familiar and universal storage of carbon in the tissues of plants and the beds of peat, lignite and coal formed of plant remains, the deposits heretofore known to be produced by vegetable life include only the limestones formed by marine algæ, certain travertine deposits and the beds of diatomaceous earth found in Tertiary and more recent formations. To these we may add deposits of silica and sesquioxide of iron, formed both by mosses and by algæ, siliceous sinter and sulphate of lime.

It has long been known that certain marine algæ, particularly the corallines and nullipores, possess the power of secreting the carbonate of lime, which they extract from sea water and of which they build their cell walls or strengthen their structures. Such plants have been recognized as important aids in the formation of the limestones and the banks of calcareous sand so characteristic of tropical seas. Agassiz has described limestones found on the coasts of Florida that consist essentially of the remains of these stony algæ.

It is now known that certain fresh-water algæ and several

species of mosses are also possessed of this power of separating carbonate of lime. The association of mosses and algæ with deposits of carbonate of lime was noticed many years ago at several European localities, and in 1862 Dr. Ferd. Cohn described in detail the manner in which travertine is formed by the mosses of Tivoli and the algæ of the hot springs of Carlsbad, and the explanation advanced by him is now generally accepted as the process by which the great deposits of travertine found at Tivoli and the beds of that substance that underlie the city of Carlsbad, have been formed.

This process is explainable on strictly chemical grounds whether the lime forms an integral part of the plant structure or merely encrusts it, or as is sometimes the case, forms a deposit that shows no trace of organic structure. The process is a simple one, resulting from the well known avidity of plants for carbonic acid gas. Water plants thus tend to impoverish the water of its carbon dioxide, thereby depriving the carbonate of lime which the water holds in solution, of its solvent. It is not necessary to suppose that the plants always decompose the bicarbonate and take up the carbonic acid thus liberated, though the fact that the mosses growing in waters containing but 0.031 per cent. of the $CaCO_3$ were found covered with a beautiful encrust of lime, while the water did not deposit that substance under exceptionally favorable conditions of evaporation, proves that it really is the action of the plants that produces the deposition of the lime. But even in waters very highly charged with carbonic acid gas, plants may produce a deposition of carbonate of lime since it is well known to chemists that the amount of bicarbonate of lime that is soluble in a water is dependent upon the volume of free carbonic acid gas it holds, which must be largely in excess of the amount necessary to form the bicarbonate, so that in such waters the withdrawal of any of the carbonic acid gas will produce supersaturation of the solution and consequent deposition of the calcic carbonate; this is actually the case both in the cold waters of the Arno at Tivoli and the hot waters of the Carlsbad springs. Observations made upon the origin of the travertine and calc sinter deposits of the Yellowstone park, show that they have a similiar origin in part at least and it is to the algous vegetation of the hot lime-bearing waters

R. Ludwig. Pogg. Ann. Vol. 87, p. 91.

which beautifies the hot spring bowls, channels and overflow slope with its brilliant and varied tints, that we must credit the formation of the unique and beautiful terraces of the Mammoth hot springs. Each peculiar type of algous growth forms its own characteristic form of travertine and we have in consequence laminated, fibrous, thatch-like and other forms of tufa.*

Deposits of iron are also formed by plant-life. It is now generally admitted that bog iron ores owe their origin to chemico-organic agencies, the iron being taken into solution by the waters through the action of the products of decaying vegetation. The final precipitation of the ore is easily accounted for by simple oxidation on the surface of the bogs or ponds and lakes, on the bottom of which the ore accumulates, but as a matter of fact it has been found that the ore sometimes consists very largely of the remains of diatoms, the iron encrusting the siliceous tests and in some cases at least forming part of the sheath itself. The oxygen given off by the living plants would be a sufficient cause of this encrustation of iron, since it would oxydize the iron to the insoluble sesquioxide. It is by this action that Bischof explains the presence of large amounts of iron found in the travertine of Nauheim. Not only does the vegetable life of these waters cause the separation of carbonate of lime by their absorption of CO_2 but the oxygen which they give off oxydizes the protoxides of iron present in the water and causes the formation of a highly ferruginous deposit.

A very striking case of ferruginous deposit clearly due to plant life was observed by the writer last summer. A spring of cold, clear and quite acid water highly charged with iron and carbonic acid gas, issued from the summit of a mound of what appeared to be iron ochre. The bowl on the summit of this mound was filled to the brim with the sparkling water and surrounded by a growth of velvety dark green moss, a species of Hypnum. Upon examining the deposit of iron forming the mound it was found to consist entirely of the stems of a moss that proved identical with that found about the edge of the bowl. Specimens were obtained showing a continuous passage of the living moss at the surface into the mineralized stalk below. The mound was several feet high and composed entirely of this deposit and an old mound

*Ninth annual report of the Director U. S. Geol. Survey. p. 619.

near by, whose bowl is now empty and dry, was found to consist of the same moss sinter.

Upon burning off the organic matter of the green and living moss the structure remains, formed of Fe_2O_3, so that the iron really forms part of the plant tissue. An analysis of this material made in the U. S. Geol. Survey Laboratory shows it to have the following composition :

SiO_2	1.37
Fe_2O_3	63.03
SO_3	8.35
Al_2O_3	0.08
Water and organic matter	26.94
Total	99.77 per cent.

In this case the iron has probably been in solution as ferrous sulphate which has been oxidized with the formation of the ferric oxide and sulphuric acid.

Although the extraction of silica to build up plant tissues is not confined to the lower orders of plants, it is only in the algæ and mosses that this property is so highly developed as to form mineral deposits. The extraction of silica from sea-water has long been recognized as one of the peculiar and as yet unexplained properties of the microscopic plants called diatoms. The well known and constant association of amorphous silica and organic matter cannot be accepted as explaining this secretion of silica by diatoms since it is manifestly a result of life or vital agency. It is perhaps unnecessary to call attention to the great thickness of the beds of nearly pure silica, composed of the remains of diatoms, which are found in all parts of the world. The largest deposits are undoubtedly those in Nevada, described by Mr. Arnold Hague in the reports or the 40th Par. Survey as being several hundred feet thick.* At the present day diatoms have a widespread distribution in both salt and fresh water and are forming siliceous strata by the accumulation of their remains, on the bottom of the ocean and also in lakes, ponds and bogs on the land.

In the geyser basins of the Yellowstone park, there are beds several feet thick and square miles in extent, which consist of the

*Reports, 40th Parallel. Vol. II.

remains of the same species of diatoms that now form the thick ooze of the warm marshes.*

The separation and secretion of silica from natural waters is, however, not confined to the diatoms. The alkaline waters of the geysers and hot springs of the Yellowstone park which are highly charged with silica, contain a vividly colored algous vegetation that produces siliceous sinter, and mosses growing in the cooled waters of certain of the springs produce rock-strata also formed of silica.

The separation of the silica by algæ is a very common phenomenon in the Yellowstone park and inferentially in hot siliceous waters elsewhere since the same algæ species occur in the hot waters of New Zealand, the Azores and other localities. The algæ extract the silica and deposit it as a hydrated jelly, that is sometimes an integral part of the plant tissue, and forms the hyaline wall of the algæ threads, sometimes encrusts the silken filaments or more often forms a thick jelly that binds together the matted felt of threads into slimy cushions or into leathery sheets that line the cooler springs of 90 degress to 130 degrees F., or occurs as a slippery coating upon a hard deposit of sinter. The evidence† is convincing and conclusive that these growths form masses of jelly that harden into and form siliceous sinter.

Equally strange is the formation of terraces of a buff-colored rock consisting of 90 per cent. silica, by the moss *Hypnum aduncum* var. *gracilescens*. This moss covers the inner and outer sides of a series of terraced bowls at the upper geyser basin of the Yellowstone park, and it was easy to show that the moss passed directly and in situ into the stone beneath. Indeed the rock itself shows at once that it is composed of the silicified (?) or siliceous stalks, of this moss. Specimens in the possession of the survey show that the silicification of the older portion of the moss stalk takes place even while the stems wave loosely and freely about in the water. The analysis of the siliceous rock thus formed shows a very low percentage of organic matter considering its origin, with a larger amount of $CaSO_3$, than either the siliceous sinter formed by algæ, or the true geyserites of the geyser basins.

*Diatom beds and diatom marshes of the Yellowstone National Park, by Walter Harvey Weed. Botanical Gazette, Vol. xiv, No. 5, p. 117.

†Ninth Ann. Report Director U. S. G. S. Formation of Hot Spg. Deposits. Walter Harvey Weed. p. 655.

SiO_2	89.72
Al_2O_3	1.02
CaO	2.01
H_2O	7.34
Total	100.09 per cent

Both the deposits of silica formed by mosses and those resulting from algous life are notably pure, containing less clay than is usual in the true geyserite formed by evaporation.

It has long been known that certain algæ, called Beggiatoa, are the characteristic inhabitants of sulphur springs, and the white slimy masses which they form were at first considered to be a lifeless organic substance precipitated out of the warm waters. In studying these algæ it was noticed that they were often associated with deposits of sulphate of lime and that the minute threads were encrusted by sulphur. Cramer and other observers proved that the filaments contained granules of amorphous sulphur. In common with other students he supposed this sulphur to be derived from the deposits of sulphate of lime and from the soluble sulphates present in the spring waters. Quite recently, however, it has been shown by the painstaking and convincing experiments of Winogradsky, that these plants actually form deposits of $CaSO_4$ in the following manner. Unlike other algæ, the Beggiatoa subsist upon and are nourished by H_2S which the sulphur waters contain in greater or less quantity. This they decompose into water and sulphur, the latter being secreted within the algæ threads in amorphous white granules. These immediately crystallize upon the death of the plant, but during its life are oxydized to H_2SO_4, which is immediately neutralized by the carbonates present in the water and forms sulphates, and if $CaSO_4$ be present in large quantity it is deposited as gypsum.

If the results outlined above are attained in this way (and there seems no reason to doubt the careful experiments mentioned), the Beggiatoa stand alone in the vegetable world. That the sulphur is necessary to the growth of the plant was proven by the impoverishment of the plant as the sulphur was consumed and its death when the supply was exhausted.

It is believed by the French biologist Parize* that microbes

*Trouessart—Microbes, Ferments and Moulds. Inter. Sci. Series. No. 56, p. 124.

may perform a geological part in nature by disintegrating the schistoid rocks, which enter into the constitution of arable soil.

The examples cited and described show therefore that the pro duction of mineral deposits by plant life is neither a rare nor an insignificant phenomenon of chemical geology, and is further proof that very important geological results are often achieved by the most lowly organized forms of life.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

On burrows and tracks of invertebrate animals in paleozoic rocks, and other markings. SIR J. W. DAWSON. (Quart. Jour. Geol. Soc., Nov., 1890, vol. xlvi.)

This paper consists of critical notes and comparisons, illustrated by graphic reproductions (from photographs) of several of the problematical markings that are familiar to the geologist under the names of Bilobites, Protichnites, Climachtichnites, Scolithus, Arthrophychus, etc., and which are very often hastily grouped under the comprehensive and vague term "fucoids." The author has made use of the abundant material of this nature belonging to the Peter-Redpath museum at Montreal, collected by himself at the time of the enlargement of the Grenville canal, on the Ottawa river, and added since by Lt.-Col. Grant from the vicinity of Hamilton, Ontario.

The author considers six genera as the burrows and tracks of marine animals, probably crustaceans, as he had pointed out in 1864 (Can. Nat. n. s. vol. i. pp. 363, 458). viz.: Rusichnites, Arthrichnites. Cruziana, Climachtichnites, Fræna, and Crossochorda. The first two are names substituted respectively for Rusophycus, of Hall, and Arthrophycus, of Harlan.

Different generic names have been given to some tracks closely related which the author would apparently regard as unworthy of generic rank, as they exhibit a variability that seems dependent on the nature of the sea bottom, or on the various modes of progression. They pass into Protichnites, of Owen, and into the worn tracks of the genus Nereites, of Hall. The same trail sometimes passes through the different characters of Cruziana, Crossochorda, and Nereites, though Nereites was supposed by Hall to be formed by molluscs. He shows by comparisons with tracks of modern Limulus, polyphemus that both the Protichnites and the Climachtichnites may have been formed by some of the earlier crustaceans which had a divided and truncated tail. This would account for the ridge sometimes dividing the furrows and transverse ridges, and for

its change of position from side to side of the mesial line, also for the interrupted ridges on each side of the trail which would be the natural results of the successive strokes of a flat organ, and for the appearances presented when the tracks turn abruptly, or when they end abruptly as if the animal had suddenly risen from the bottom.

He suggests that the roofed burrows, resembling the forms known under the name Phytoderma, may have been produced by a burrowing crustacean of Silurian times.

Scolithus he unhesitatingly ascribes to worm-burrowing, and he gives evidence that goes to indicate that several genera that have been created (Monocraterion of Torell. Pyrophyllites, and Asterophycus) are to be ascribed to the burrowing of the same animal or to its trailing about the openings of the tubes.

A new genus (Sabellarites) is described by the anthor, and to it he assigns two species, viz.: S. trentonensis and phosphaticus. This name is given to tubes which are composed of fragments of shells, corals, sand, or phosphatic coprolites, the former from one-tenth to one-eighth inch in diameter and three centimeters or more in length, found in the Black River limestone near Montreal, and the latter in the Hastings group, which he considers now as probably Huronian, or "primordial." These tubes he compares with those that are constructed by the modern genus Terebella which consist of grains of sand and fragments of shells attached to a membranous lining. This shows a remarkable antiquity for that method of life and protection against predatory aquatic enemies which is found illustrated by the fresh water sheaths with which our ponds and streams are supplied.

The author draws attention to the characteristics by which true fucoids may be distinguished from the foregoing, and mentions Buthotrephis gracilis, giving also two illustrations of B. granti.

Various combinations of animal tracks and rill-marks, and even of rill-marks alone, have been described as genera of fucoids. Such are Dendrophycus, Delessorites, Vexillum, Aristophycus, Chloëphycus, Tricophycus and Dictuolites.

Experiments on the constitution of the natural silicates. F. W. Clarke *and* E. A. Schneider. (Am. Jour. Sci., Oct., Nov., Dec., 1890.) The authors have made a series of experiments on six groups of magnesian silicates, viz.: olivine, talc, serpentine, chlorite, mica and vermiculite, using in some cases samples from several localities. The test experiment, after ordinary quantitative analysis, and the purification of the material, or the determination of its inclusions, was the subjection of the ground mineral to dry hydrochloric acid gas at a temperature between 383° and 412° C., *i. e.* between the fusing points of lead iodide and zinc. The effect was different on different minerals. This was then compared with the effect of aqueous hydrochloric acid on the same minerals, sometimes after strong ignition. It was found that sometimes a species previously soluble could be thus split up into a soluble and an insoluble part.

They conclude (1) that the actions of gaseous and aqueous hydrochloric acids differ widely ; (2) that in this group of minerals the gaseous acid attacks apparently only that part of the magnesium which is present as the univalent groups—Mg—OH ; (3) the chlorites are not hydrated conditions of the micas, or micas plus water of crystallization.

Corals and Coral Islands. By JAMES D. DANA. Third edition, pp. 440 ; with 16 plates, and many figures in the text. (New York : Dodd, Mead & Co., 1890.) Eighteen years have elapsed since the first publication of this well known popular work, which is based on observations made by the author long before, during the cruise of the Wilkes Exploring Expedition in the years 1838 to 1842. Changes and additions have been made in all parts of the work to bring it up to the present date ; and about thirty new pages are inserted, meeting objections to the subsidence theory of Darwin and Dana. The views of Murray, Guppy, A. Agassiz, Semper, and others, accounting for coral islands without subsidence, are shown to be improbable. "Darwin's theory, therefore, still remains as the theory that accounts for the origin of atolls and barrier islands, which is not true of any other that has been proposed. Fringing reefs and isolated coral-reef banks may form in shallow water within the growing depths of reef-making corals, and on any kind of bottom. But atolls, barrier-reefs, and coral formations of great thickness require as a rule, the aid of slow subsidence, —as has been true for nearly all the thick rock formations over the continents."

The area of the Pacific ocean-bed which thus appears to have been sinking has a length of more than 6,000 miles, with a breadth of over 2,500 miles, and in its central portion the subsidence is believed to have amounted to several thousands of feet. It has been in progress, according to professor Dana, from sometime in the Tertiary era until now, probably affecting its maximum area during the glacial period. Correlative with this downward movement for the tropical Pacific, and perhaps for some portions of all the oceanic areas within the tropics, the continental lands of North America and northwestern Europe, which were glaciated, experienced an upward movement, as the author concludes, of similar amount, producing a colder climate and ice-sheets.

On the Geology and Physiography of a portion of northwestern Colorado and adjacent parts of Utah and Wyoming. By CHARLES A. WHITE. pp. 677–712 : plate lxxxviii ; figures 57–61. (Accompanying the ninth annual report of the director of the U. S. Geological Survey.) This paper, which relates to the district covered by Powell's *Geology of the Uinta Mountains* (1876), describes the eastern part of the Uinta range, cut by the Horseshoe, Red, and Lodore cañons of Green River ; the nearly related Yampa plateau and other subordinate folds south and southeast from the east end of the great Uinta anticlinal ; the inceptive eastward continuation of this anticlinal, to the base of the White River plateau, a spur of the Park range of the Rocky mountain system ; and the small upthrust Junction and Yampa mountains, which are isolated

ellipsoid anticlinals of very steep dips and faults, respectively about twelve and seven miles long, situated east of the Uinta mountains, on the low, inceptive portion of their broad fold.

The geologic formations exposed in the Uinta anticlinal, as made known by Powell, King, Hayne, Emmons, and White, are the Uinta sandstone, 12,000 to 14,000 feet thick; Carboniferous limestones and sandstones, 3,000 to 4,000 feet; Jura-Trias strata, mostly sandstones, 2,500 to 5,000 feet; and the Dakota, Colorado, Montana and Laramie series of the Cretaceous system, aggregating 6,000 or 7,000 feet. Overlying the edges of this mountain mass, and included with its uplift in successively diminishing amount of tilting, are the Wahsatch, Green River, Bridger, and Brown's Park fresh-water Tertiary formations, with aggregate maximum thickness of 7,700 feet.

Elevation of the great Uinta fold began, according to Dr. White, at the close of the Laramie period, when epirogenic movements finally cut off the brackish Laramie sea from all connection with the ocean. The folding and uplifting were in progress during the Eocene epochs of the Wahsatch, Green River, and Bridger lakes; and were nearly completed before the deposition of the Brown's Park beds, which rest unconformably upon all the other formations and are probably of Pliocene age. The vertical extent of the Uinta uplift, occurring thus during the Tertiary era, is shown to have been about 28,800 feet, or five and a half miles; but, owing to erosion, the range has probably never greatly exceeded its present hight of 10,000 to 13,000 feet.

In the small Junction mountain and Yampa mountain upthrusts, the vertical displacement of each has been nearly 12,000 feet, and this has taken place contemporaneously with the Uinta uplift. Indeed, Dr. White finds, by the extension of his observations and study eastward from the Uintas to the Park range of the Rocky mountains, that both these prominent ranges, their subordinate folds and spurs, and the two upthrust mountains, are all "results of one great system of orogenic movements." So slow has been the elevation, however, not only of the Uinta range, but also of the isolated Junction and Yampa mountains, that rivers which traversed their areas when the uplifting began, have not been turned out of their courses, being able to erode and deepen their cañons through these mountains as fast as their rise, to total hights of two to five miles, progressed.

Nicholson & Lydekker's Palæontology:—The second volume of this great work comes from the pen of the latter of the two authors who are associated on the title page. Mr. Lydekker's name has been familiar to the student of vertebrate palæontology for many years past, and no one will dispute his competence for the task. His introductory chapter on the comparative anatomy of the various classes of the sub-kingdom Vertebrata, forms an excellent summary of our present views regarding the relationship of their organs in the light of Evolution.

Passing over as an unsolved problem the origin of the Vertebrata from the invertebrate sub-kingdom the author selects from the totality of the

animal organism those parts which are important for his purpose, and concentrates his attention on them. These are the bones, the teeth, and the skin, and appendages if hardened as is frequently the case. It is from these, that the palæontologist must study the vertebral life of the past for seldom have the soft parts left any impress or record of their existence.

In dealing with the fishes, the classification of Prof. Huxley is preferred to others that have been proposed as more in accord with the systems adopted in other classes of Vertebrata. This places the Cyclostomata by themselves. These however, being unknown in a fossil state require no notice.

Dealing with their geological age the author remarks that being the lowest of the Vertebrata, their remains would naturally be looked for in rocks of very early date. This expectation is fulfilled. "The earliest known fishes in Britain occur in the Lower Ludlow group of the Silurian." The *Palæaspis* of Pennsylvania however, from the Onondaga group represents an older date, probably coëval with the Wenlock, while the *Onchus pennsylvanicus* of the same state, from the Clinton, corresponds in age with the upper part of the Llandeilo or the "May-hill" sandstone. These indicate a rather greater antiquity for both ganoids and elasmobranchs.

The elasmobranchs, have been a very important order from early times. But as their skeletons are and were almost entirely cartilaginous we are compelled to depend on the evidence of teeth, spines and dermal scutes for their restoration with the aid of an occasional and unique specimen where an impression of some parts of the body may have been preserved.

A singular fact in this connection is the frequent occurrence of thin beds composed almost entirely of the teeth, bones and scutes of these and other fish. Such are the well-known Ludlow bone-bed of Silurian age, and the Rhœtic bone-bed in England, both of which though only an inch or two in thickness are remarkably persistent. The Delaware bone-bed of Corniferous age in Ohio is another case in point. They are apparently beach-lines or wash-deposits and indicate a much greater abundance of fish-life at those eras than the ichthyic remains found elsewhere would lead us to suppose. At the same time we must not forget that in naming genera and species from detached teeth and spines, the palæontologist is often obliged to represent several parts of the same animal by distinct names, and the mistake is often made by those who are unfamiliar with his material of supposing that each of these names is intended to connote a separate organism. So far is this from the truth, that the term species has in palæontology in many cases an entirely arbitrary meaning and implies no belief in any connection such as is intended in recent biology. For the progress of science it is necessary to name these fossils, but the palæontologist holds all such names at their real value and waits till some lucky find shall enable him to put together two or more as only the separate parts of a single being.

One need only take a glance at the dentition of the Port Jackson shark, to see how readily such double naming may occur. This remark is yet more pertinent in the case of fossil botany.

Thus Mr. Lydekker remarks: "It is probable that some of the dorsal fin-spines, originally described under the name of Ctenacanthus belong to Orodus (more properly Oreodus). Most of these spines are however referable to the allied Carboniferous genus Sphenacanthus."

In regard to the remarkable fossil Edestus the author accepts Dr. Newberry's opinion that "we may regard them as the dorsal spines of large cartilaginous fishes of which the other parts are as yet unknown and may suppose that they were used for attack and defence as the spines of Trygon or of Acanthurus."

Fossil chimæroids are comparatively few and chiefly Mesozoic or later in date, Rhynchodus and Ptyctodus being the most important forms of reputedly palæozoic age.

On the other hand the Dipnoans indicate an essentially ancient origin by their wide distribution over the world of their few remaining representatives.

The great, but difficult order of ganoids, as the term is here employed, includes nearly all the oldest fishes such as Cephalaspis and Pteraspis and those Old Red sandstone fossils with which the writings of Hugh Miller have made us all familiar.

In this connection we may remark that we believe that the sensory system has not been found in the shield of the *Cephalaspidæ* though it is now known to have existed in the shield of the *Pteraspidæ*. There is also some error regarding the locality of *Holaspis* but Lankester's paper is not at hand to supply the correction. No Pteraspidian except *Scaphaspis* is known from undoubted Silurian rocks in England so that *Auchenaspis* from the passage-beds of Ledbury, and *Didymaspis* of which only a single specimen is known, should be referred to the Devonian. *Scaphaspis* is now by many considered the ventral shield of *Pteraspis*, but in this case it is not easy to understand why it alone should be found in the Lower Ludlow. Only a very few specimens are known, but possibly more than one species is included in them. The *Diplaspis* of Matthew should have been here mentioned, from the Silurian strata of New Brunswick containing a marine fauna resembling that of the English Ludlow. According to its author's description this species had a ventral as well as a dorsal shield.

Here also belong those gigantic fossils, which have been recently brought to light from the Black Shale of Ohio, such as Dinichthys and the yet huger Titanichthys. The order is distributed by the author into twenty-six families. It is needless to add that he adopts in this department, the recent work of Mr. A. S. Woodward and Dr. Traquair for Great Britain and of Dr. Newberry for North America.

The teleosts are, says our author, in all probability descended from the ganoids and occupy in the class a somewhat analogous position to that held by the Squamata among the reptiles and the Passeres among

birds; all traces of reptilian affinities having been lost in this order. The order is treated under a great number of families, only a few of which are of palæontological importance. The siluroids have suggested to Prof. Huxley by several points of resemblance a near relationship to the ganoids. But a difficulty occurs in the fact that they are not known with certainty before the Tertiary era. Of especial interest is the family of the horse-mackerels (Carangidæ) on account of the excellent preservation of its fossil specimen in the Monte Bolca Eocene of northern Italy, a series of limestones associated with volcanic material which has yielded to the labors of Agassiz 133 species of fish represented by immense numbers of specimens. Of the flat fishes we have almost no fossil remains, only two genera, the turbot and sole, being known.

The introduction of the teleostean fish is of very recent date, none of them having been found fossil in rocks older than the Cretaceous. They are essentially Tertiary in date, but have advanced so rapidly in number of species and of individuals that they form to-day a very large majority of the existing fishes of the globe.

The Amphibia are a class of very great interest to the palæontologist as they form a transition group between fishes and reptiles. The survival of this class to the present day has enabled the evolutionist to bridge over a chasm which would otherwise have existed between these groups. Of the whole class, however, only one order, the labyrinthodonts, is geologically ancient. Of the Apoda no fossil remains are known, while the salamanders, frogs, and toads are only found in later Tertiary strata. This leaves an enormous gap in the geological history of the class, the latest known labyrinthodonts being found in the Trias and the earliest of the other orders in the Tertiary or possibly and doubtfully in the Cretaceous. They are especially characteristic of the latest part of the palæozoic era and of the earlier Mesozoic ages. From the Carboniferous to the Trias in Europe and North America their remains occur, but only a single genus, says Mr. Lydekker, ascends to the Lower Jurassic. Their remarkable and complicated tooth-structure from which the name is derived characterizes the greater part of the order, though in a few this feature is wanting.

In this connection we may note the fact that not a few of the labyrinthodonts were first known by their footprints in double series with a small fore and a large hind track. *Cheirotherium*, or rather *Cheirosaurus*, was the earliest of these in date of discovery, but the records of this kind drawn from the sandstones of the Connecticut valley by the labors of the Messrs. Hitchcock, have surpassed all found elsewhere, and unmistakably prove an abundance of labyrinthodont and other life in the Trias. Thousands of these footprints have been extracted from the quarries and tens of thousands more have been destroyed.

The gap above alluded to in the history of the Amphibia would lead us to seek the origin of the class of reptiles in the labyrinthodonts, for undoubted members of this group appear as early as the Permian and possibly in Carboniferous days. But the teeth of true reptiles never

show the complicated enamel folds that characterize the labyrinthodonts. They may be anchylosed to the outer side or to the summit of the jaw, or they may be set in distinct sockets, and in many cases they are continuously renewed during life. The form of reptilian teeth is simple, being for the most part a flattened cone.

The change which recent research has brought about in our knowledge of this class may be realized from the author's statement on page 1057.

"As regards the classification of reptiles scarcely any two writers agree. There is little difficulty with existing forms, but when we go back to the early part of the Mesozoic era we find that nearly all the orders into which the class has been divided show such signs of passing into one another that it is quite impossible to exhibit their relationship by any system of linear classification."

In view of this difficulty the author provisionally adopts, with some slight change, the classification proposed by Dr. Baur, now of Worcester, Mass., in which they are divided into ten orders. Of the first of these the anomodonts (Theromora or more correctly Theromorpha of Cope). He says the evidence shows almost conclusively that its members are descended from the labyrinthodont amphibians and more especially from the archegosaurians.

The difficulty of classification and the increase of our knowledge of the phylogeny of the Reptilia is in great part due to the rapid progress of discovery in this field. Recent researches, especially in the Jurassic strata of the western states have brought to light an immense number of forms for which no place could be found in any previous system. Many other species are known only from a single bone in some geological museums, and of these several will ultimately perhaps be proved to belong to the same animal.

The shapes assumed by some of these fossil reptiles are most extravagant. In *Dimetrodon* the neural spine was according to Cope twenty times as long as the centrum and formed an elevated fin, while in *Naosaurus* which is figured by Mr. Lydekker, a similar neural spine carries six projecting cross processes on each side. *Dicynodon lacerticeps* has the "canine" teeth of a tiger in a skull twenty inches long, while its near relative *Oudenodon* (Udenodon) was toothless. The familiar *Plesiosaurus* had the long neck of a swan combined with the head of a lizard and the paddles of a turtle. *Testudo* (*Colossochelys*) *atlas* measured six feet in length and was probably the largest tortoise that ever existed. *Ichthyosaurus* was thirty feet long with the head of a crocodile and eye-sockets six inches in diameter. It was carnivorous and its coprolites prove that its food consisted in great part of ganoid fishes, while the frequent presence of uninjured young in the body-cavity tends to prove that it was viviparous in some species at least. This genus, the type and almost the only component of its family, has not been found in America. *Hyperodapedon* had no teeth but its jaws were encased in hard horny beaks like those of a falcon, the upper being strongly hooked.

The author figures the classic *Mosasaurus* of Mæstricht found in 1785 and for nearly a century the only specimen of the genus. This specimen which had some singular experiences during the war in the "Low Countries" is inferior in one important respect to others which have been since found in the Cretaceous of North America, inasmuch as the displaced pterygoid bone conceals the joint in the ramus of the jaw that is a peculiar feature in the family of the *Mosasauridæ*, and, according to Baur, in at least two others, the *Varanidæ* and the *Helodermatidæ*. So complete is the concealment of this feature that its very existence was unknown until the American specimens were found.

Of the dinosaurians the author writes: "They comprise the largest land reptiles and while some of them approximate closely to the type of structure obtaining in birds others come so near to the more generalized crocodilians that it is almost impossible to separate them from the latter." Here belong the long known *Iguanodon*, the subject of the labors of the late Dr. Mantell; the *Hadrosaurus*, first described from the Cretaceous of North America but since found in Europe, the only skeleton of which is in the museum at Princeton, N. J., the work of the late Waterhouse Hawkins; the immense *Megalosaurus* and horned *Ceratosaurus*, *Ceratops*, with beak-like skull and one or more pairs of horn-like processes resembling those of cattle; *Brontotherium* of North America and Europe, estimated at 50 feet in length and 20 tons in weight, and lastly the but partially known *Atlantosaurus* with a femur more than six feet long and probably the largest land animal yet known.

Among the Reptilia also occur the strange flying Pterodactyles, perhaps the earliest animals, insects excepted, which possessed the power of rising into the air. Geology has not revealed the remains of any true bird of date coëval with them. They were not, however, birds at all, but flew as bats, by the aid of flaps of the skin carried on the enormously developed phalanges of the limbs. "The greater number of the bones were hollow and frequently provided with pneumatic foramina as those of birds. The brain was bird-like and the skin was probably naked. The order ranges from the Lias to the Upper Chalk. In spite of the many remarkable resemblances in structure to that of the carinate birds it is clear that the Pterodactyles are altogether off the line of direct avian descent." In some of these strange animals the teeth are totally absent (Pteranodon). In others both jaws are toothed to the extremities. Some were small—only a few inches in length; others had a spread of wings equalling twenty-five feet. All have long been extinct.

Leaving the reptiles for the birds, we pass over what was once considered, perhaps, the greatest gap in structure in the whole animal kingdom. The transition from the cold-blooded, creeping reptile to the hot-blooded bird is certainly as great as can well be imagined. But this gap has been so completely filled with the many forms that palæontology has discovered that it has absolutely disappeared and the difficulty now is to distinguish the bird from the reptile. The only evident external

mark that remains is the presence of feathers "which are totally unknown among reptiles." Even this test however would fail if some of the earlier feathered forms were ranked (as they well might be, this single character apart) with reptiles. One of the most remarkable chapters in palæontology and in the evolution of animal life is that in which is traced the discovery of the forms intermediate between these two groups. Scarcely a link is missing. *Archæopteryx*, the reptile bird of Solenhofen, led the way, if we omit some possibly avian footprints in the Connecticut valley, and was, after a long interval, followed by the toothed Hesperornis of North America, the toothless *Aepyornis* of Madagascar, and the *Apteryx* of New Zealand.

Among the carinate birds to which most of the existing species belong we have also a toothed and a toothless series, the former extinct and consisting only of the genus *Ichthyornis* which the author places here, rejecting the order of *Odontornithes* proposed by Marsh to include this and *Hesperornis*.

The toothless division of the carinates includes a number of forms many of which are almost recent, some having been exterminated by the agency of man. None are older than the Cretaceous and by far the greater number are only of Tertiary age. They include among others a penguin, the great auk, woodcocks and plovers, bustards, cranes and rails, turkeys, pheasants, and grouse, quails and pigeons, the Dodo of Mauritius, geese and ducks, albatrosses and frigate-birds, vultures, falcons, and buzzards, owls, parrots and cockatoos, kingfishers, woodpeckers, swallows, sparrows, crows, etc.

On the whole the story of the evolution of the bird is the most wonderful that has been read to us by the palæontologist and it has been well brought up to date by the author. The type specimens are scattered in the various museums over so large an area, and the literature of the subject is dispersed in the journals and proceedings of so many scientific societies, that it has been no light task to collect it as he has here done.

Of the characters of the Mammalia a few only can be employed in palæontology—those for the most part belonging to the hard parts of the body. The double articulation of the cranium with the atlas, the firm union of the rami of the lower jaw, the absence of a quadrate bone and of a moveable joint between the proximal and distal tarsal bones are the most important and useful. The structure of the teeth is of the first value, both for the identification of fossil forms, and for the tracing of ancestral lines. As might be expected from the author's long experience, and great familiarity with his subject, the work is well down to date in these respects. All the latest researches on the evolution of the multituberculate mammalian tooth from that simpler conical and unituberculate tooth that characterized the reptilian predecessors and ancestors of the Mammalia are brought into service, and it is easy to perceive that though many gaps still remain, yet the line of the development of these organs is rapidly being traced and filled. These results

are largely due to the labors of American palæontologists working on the abundant material that the new states of the west have afforded.

The chasm existing between the mammals and the reptiles is now more obvious than that which formerly existed between the latter and the birds. But just as the one has been almost filled up, so the other is rapidly becoming less profound and abrupt. The few links supplied by the scanty existing marsupials and monotremes are of inestimable value, while the fact that all the most ancient fossil mammals belong to one or other of these groups is intensely significant as indicating the line of descent.

Only three monotremes are known now to be in existence, the duck-bill and two ant-eaters in Australia and in New Guinea, and these the author says, cannot be regarded as ancestral types. It is worthy of remark that though the monotremes hold the lowest rank among the Mammalia, yet the oldest mammalian fossils are placed by all among the marsupials—an inversion of the order of development probably due to the imperfection of the record. This is far from surprising when we look at the very scanty nature of the material that we possess regarding these early animals and that this little is in most cases limited to a few lower jaws and teeth. No fossil monotreme has yet been found of earlier date than the Upper Triassic and these are only two detached teeth of *Microlestes* and one of *Triglyphus* (*Tritylodon*). The slowness with which the early mammalian remains are coming to light is very remarkable. Nearly fifty years have passed since Prof. Pleininger found the two teeth and a few small fragments of bone of *Microlestes* near Stuttgard, and Prof. Emmons met with three jaws of *Dromatherium sylvestre* in North Carolina. Yet in all this long interval no other specimen of these has been discovered and only one species has been added to the scanty list in a single tooth of Tritylodon. Nature seems to be unwilling to disclose her first imperfect attempts at producing the Mammalia —she hides "her 'prentice han'."

From the Triassic to the Eocene, over-leaping the Jurassic and Cretaceous systems, we must pass before we find the earth tenanted by any higher form of mammalian life than the marsppials. In the Eocene we meet the earliest specimens of the *Edentata*, or sloths, a peculiar order widely differing from these above them in their imperfect dentition which exhibits some indications that may be construed to imply degeneration.

It is not a little singular that no remains of fossil sloths have been found in Europe, nor does any animal of this order inhabit that continent at the present day. South America is now, and apparently has always been the metropolis of slothdom. There lived the *Glyptodons*, huge armadillos six and eight feet in length; *Megatherium*, *Scelidotherium* and *Mylodon*, sloths rivalling the Rhinoceros in bulk and capable of pulling down for food, the trees, which they were unable to climb.

Most of the fossil *Edentata* are of late Tertiary date—Pliocene or even

Pleistocene—the genera *Moropus* and *Morotherium* of Marsh being rejected from this order and referred to the Ungulata.

Like the *Edentata*, the cetaceans first occur in the Eocene but abounded in later eras. Their exact ancestry is at present unknown though there is little doubt that they have descended, as Flower has suggested, from forms resembling the present ungulates. The same author infers that they at first inhabited fresh-water, in as much as their remains have not been found in the Cretaceous rocks. All are now, however, marine.

The sirenians also occur first in the Eocene, and have ever since "been steadily dying out." To this result man has contributed by exterminating the sea-cow of Behring's Island, about 120 years ago. Only one or two skeletons of this remarkable animal are now known in the museums of the world. The palæontological importance of the Sirenia is small.

The ungulates are palæontologically the most important of all the mammalian orders. Of the seven suborders, into which it is divided, only four contain living species. Of the three extinct suborders one *Amblypoda*—contains the huge *Coryphodon* of England, and North America, the *Uintatherium* of Wyoming, and some other similar forms. The palæontology of one of its families—the *Dinocerata*—affords a good illustration of the fragmentary condition of the geological record. The author quotes the following from Prof. Marsh:

"The fossil remains of this group have hitherto been found in a single Eocene lake-basin in Wyoming, and none are known from any other part of this country, or of the Old World. These gigantic beasts which nearly equalled the elephant in size, roamed in great numbers about the ancient tropical lake in which many of them were entombed."

The suborder *Condylarthra* is also entirely extinct and was principally Eocene in age. Its most interesting member was *Phenacodus primævus* from the Lower Eocene of North America, an animal which Prof. Cope regards as the original type and probably the ancestor of all existing ungulates.

Of the suborder *Toxodontia* all the species are also extinct. They were apparently intermediate between the *Perissodactyla*, *Proboscidea*, and *Rodentia*.

Two other of the suborders of the ungulates are apparently on the verge of extinction, the Hyracoidea which contains only two genera, and the *Proboscidea* which now has but two species. These latter—the elephants of India and Africa—alone on earth now represent the group which contains the well known fossils Dinotherium, Mastodon and Mammoth.

To the two remaining suborders—the *Artiodactyla* and the *Perissodactyla*—belong the great majority living and extinct of this order and on them consequently the greatest interest and attention are concentrated. It is needless to remark that the subject is treated with a fullness and care which the great experience and learning of the author would lead us to expect. Space forbids anything like analysis and re-

mark upon the article. On one point alone we will venture to express dissent. Writing of the ancestry of the horse he says:

"Considering that a parallel series of generically identical or closely allied forms occurs in the Tertiaries of both Europe and North America, it has been suggested in both continents a parallel development of the same genera has simultaneously taken place, that is that in both regions *Anchitherium* has given rise to *Hipparion*, and *Hipparion* or an allied form to *Equus*. Now seeing that it is evident that in the case of species of a single genus the evolution has taken place in separate lines, that is to say, that the existing Indian species of *Canis* are probably derived from the Pliocene forms of the same region and the Brazilian species of that genus have their predecessors of the Cave-epoch of that country, there appears no logical reason for refusing to admit an analogous parellel evolution in the case of genera, and there is, accordingly, a considerable probability that the hypothesis may be true. Prof. Cope considers that in one country *Protohippus* and in the other *Hipparion* was the immediate ancestor of *Equus*."

In regard to this we may be allowed to remark that if we understand the hypothesis aright there is a very wide difference between the two cases. While all the *Canidæ* of one country may have been derived from the Tertiary *Canidæ* of the same region we do not know any case in which this process has resulted in the production of an identical species in two places. It seems scarcely credible that conditions should in two distant areas be so closely alike as to yield the same outcome. The admission of this position consequently does not lend any support to the other. That two distinct lines of descent through distinct genera should end in producing a single and intensely specialized species on the two continents is to our mind in the highest degree improbable. Moreover, when we consider that communication has been repeatedly opened between the continents during the Tertiary era it is not necessary to maintain a hypothesis that makes so great a demand on faith. It seems a more probable view that after reaching a certain stage of development on both continents the race was cut off on one and then reintroduced from the other.

A few pages only are devoted to the Rodentia which excepting Castoroides, are chiefly small. The Carnivora are well treated in 35 pages.

The Insectivora and Cheiroptera follow, and the author then reaches the primates. It is not a little curious to note that this—the order to which man belongs—is of a date as early as any of the placental Mammalia, several species of the platyrhine section occurring in the lower Eocene of North America and in the upper Eocene of Europe. The Catarhines, however, only appear in the Miocene while the *Hominidæ* are, in the author's opinion, of Pleistocene or very late Pliocene date. He considers, and with justice, that all evidence of an earlier date for man is at least uncertain, if not improbable.

In conclusion it is refreshing to the classical palæonotologist to see the author's efforts to reduce wherever possible the barbarisms which

have been inflicted on the nomenclature of the science by ignorance and recklessness. In not a few cases they have corrected errors in spelling and formation by giving the proper term as *Xenaspis*, *Hypsodontidæ*, *Platycarus*, *Hoplosaurus*, etc., and they recommend the form *Theromorpha* instead of *Theromora*. Other valuable suggestions in the same direction are also made, the adoption of which would much improve the literature of palæontology without in most cases any countervailing disadvantage.

Of the care and accuracy that mark the execution of the work it is impossible to speak too highly. Some evidence of them can be found in the fact that in a thorough examination for various purposes we have detected only a single misprint in all its 1,500 pages—*Rhynchodes* for *Rhynchodus* (on page 952). This is, as might be expected, repeated in the index.

We shall not, at present at least, follow our authors through the palæobotanical part of the work where we miss the master-hands so evident in the palæozoölogical. This part is confessedly only a compilation, but a good one, of our present knowlege of the subject. We leave them with a feeling of gratitude for the great work which they have acomplished and with the hope that they will live to bring out another edition which the progress of their science will assuredly before long render necessary.

CORRESPONDENCE.

Dr. Franklin C. Hill, Curator of The Geological Museum at Princeton College, for some years past, died in the early part of November. Though not well known to the outside world, Dr. Hill was an enthusiastic worker in his department, and the museum in his charge will long be a witness to his skill in arranging, and his neatness and clearness in labeling his specimens. Some years ago Dr. Hill published a pamphlet illustrating the plan he had adopted of mounting every vertebrate bone so as to show its natural place in the skeleton. This system gives great additional value to the series of fossil Vertebrata at Princeton.

Dr. Hill is also well known to entomologists for many valuable observations and for a set of large drawings (since photographed and kept for sale) of the stag-beetle—*Lucanus cervus*, and the ground beetle—*Harpalus caliginosus*, showing full details of their anatomy.

E. W. Claypole.

Prof. W. M. Davis on the Iroquois Beach. The critical note, in the December issue of the Geologist, on the Iroquois Beach by Prof. Davis needs no other reply than a calling of attention to his remarkable

confusion of different papers, by different authors, on different subjects. It is he, not I, who hypothecates that "a large river ran out of lake Iroquois to the southwest," up an elevation of several hundred feet; hence his remarks are not germane to my memoirs—"The Iroquois Beach; a Chapter in the Geological History of Lake Ontario." Trans. Roy. Soc. Can. 1889; or the paper on "The Deformation of the Iroquois Beach and Birth of Lake Ontario." Am. Jour. Sc. Vol. xl, Dec. 1890.

J. W. SPENCER.

THE ORGANIZING COMMITTEE INT. CONG. GEOL. I notice I have made unintentionally a grave error in the report I sent you for the AMERICAN GEOLOGIST, from copying the list of members of the committee from the original list instead of as afterwards added to. Please add the names of T. Sterry Hunt, Persifor Frazer and E. D. Cope, and if the article has already gone to press, have this letter inserted as soon as possible with my sincere apology for this error, which I have just noticed in my copy of the article sent you. Cordially yours,

H. S. WILLIAMS,

Sec. of the Organizing Committee, Int. Cong. Geol.

Ithaca, Nov. 27, 1890.

THE VOTE OF THE BUREAU INT. CONG. OF GEOL. CHANGING THE SESSION FROM PHILADELPHIA TO WASHINGTON. An official communication from Prof. H. S. Williams, Secretary of the Committee on Organization of the International Congress of Geologists in the last number of this journal calls for a few words of comment.

It will strike those who know the facts strangely, that in what purports to be an authentic list of the members of the committee the names are omitted of just the only three members who have persistently opposed the absorption of the Congress by the U. S. Geological Survey, and the change of its place of meeting; viz: Drs. Hunt, Cope, and Frazer. This omission, however, was accidental and has been satisfactorily apologized for by the Secretary, both by a correction to appear in this number, and by a personal letter to myself. The following paragraphs, however, remain open to explanation, viz:

"Thirty-six ballots were received: of these *thirty-three were in favor of Washington.*

"These *represent the members* from Great Britain, France, Germany, Australia, Austria, Belgium, Hungary, India, Italy, Portugal, Roumania, Russia, and the United States. No negative votes were received from countries outside of America.

"The majority of the Bureau as well as a majority of the American Committee, thus *expressing their preference for Washington*, it was voted to hold the next session of the International Congress of Geologists in Washington," etc., etc.

Of the English members of the Bureau, Dr. C. LeNeve Foster wrote to the undersigned (June 15, 1890): "We in Europe must do whatever you decide in America." Dr. Barrois of France wrote (June 28, 1890): "It

appears to me difficult to interfere in the geological struggle between Washington and Philadelphia. It is essentially an American affair and you do not like old Europe to meddle in your affairs; but you appear to me to be largely in the right," etc., etc.

Dr. V. Zittel, of Germany, in reference to the question of postponing the Congress, takes the following ground: "I would leave the decision of the question to the American organization committee and will agree with its conclusion," etc., etc.

The late Prof. Neumayr remarked on the same subject: "I see no objection to make if our American colleagues think it useful to the ends of the Congress."

Prof. Huxley on the same subject said: "I can only say that I shall acquiesce in the demand of the majority of my colleagues."

Col. Delgado, of Portugal, writes: "In my correspondence with Messrs. Hulke and Topley, General Secretaries of the Congress of London, while accepting the change of place of the session of the Congress from Philadelphia to Washington, I expressed myself formally to the effect that the American geologists are better able than their European colleagues to choose the city where the Congress should be held as well as to fix the time at which it should take place," etc., etc.

Prof. Vilanova y Piera, of Spain, writes: "The protest of yourself, Sterry Hunt, and Leidy against the decision of the General Committee proposing to hold our future Congress in Washington instead of Philadelphia, has caused me a disagreeable surprise. * * * Its wish [the General Committee's] in no wise, but on the contrary the agreement unanimously arrived at in London, *shall* prevail. Please, then, add to your protest that of, Yours, Prof. Vilanova y Piera."

Prof. Capellini, of Italy, writes: * * * "As for me I have determined to hold myself neutral, for the question cannot be well understood except by Americans."

Prof. James Hall says: * * * "While originally I could have had no objection to going to Washington, I now feel that we have violated faith with Philadelphia."

These are some of the responses which have been received which are far from justifying the portion of the official announcement italicized. It is not the province of the writer to explain the discrepancies between the views expressed to him by the above members of the bureau and those reported in the official announcement, nor to decide whether there be an error on the part of the General Secretaries, Messrs. Hulke and Topley, or on the part of Prof. H. S. Williams.

The undersigned merely says that the statements in Prof. Williams' report do not correspond with information obtained directly from many persons included under them. PERSIFOR FRAZER.

PERSONAL AND SCIENTIFIC NEWS.

IN SCIENCE, DEC. 5, 1890, Mr. H. M. AMI publishes a letter showing that he is not satisfied that the "Hudson River" rocks as understood by Emmons, can be correlated with the Lorraine shale. He has seen no reason, either stratigraphical or paleontological, to warrant it. He intimates that the term Hudson river, being used confusedly, and never fully defined, and apparently embracing several faunas that are distinct, might be omitted from geological nomenclature. At the same time he says there is a fauna, represented by species different from the Lorraine, apparently in the Levis part of the Quebec formation, which marks a distinct paleontological horizon, about on the horizon of the Chazy of New York, which could appropriately bear the name Quebec. This he is inclined to consider the horizon of the Citidel Hill rocks at Quebec.

DR. ANDREW C. LAWSON, LATE OF THE CANADIAN Geological and Natural History Survey, has accepted a position on the teaching staff of the University of California, at Berkeley. We welcome Dr. Lawson to the south side of the international boundary, and we hope he will conclude to become permanently identified with the scientific work of the Great Republic.

THE ALABAMA INDUSTRIAL AND SCIENTIFIC SOCIETY was organized at the University of Alabama, Thursday, Dec. 11th, 1890, with 70 members. Its objects are the promotion of the industries of the state, and the furtherance of scientific investigation of the problems arising in civil and mining engineering, geology, smelting, and the manufacture of coke.

The officers for 1891 are: *President*, C. Cadle, Gen'l Manager Cahoba Coal Mining Co., Blocton; six *Vice Presidents*, viz.: Thomas Seddon, Prest. Sloss Iron and Steel Co., Birmingham; C. P. Williamson, Prest. Williamson Iron Co., Birmingham; W. E. Robertson, City Engineer, Anniston; J. W. Burke, Prest. Tredegar Co., Jacksonville; M. C. Wilson, Prof. Natural Science, Normal School, Florence; Col. Horace Harding, U. S. Engineer, Tuscaloosa; *Treasurer*, Henry McCalley, Ala. Geol. Survey, University Ala.; *Secretary*, Wm. B. Phillips, Prof. Chem. and Met., University Ala.

The annual fee is $5.00. The society will meet three or four times a year at different places in the state, for the reading and discussion of papers, which will afterward be published. The next meeting will be held in Birmingham, Jan. 28, 1891.

THE EIGHTH VOLUME OF THE REPORTS of the Geological Survey of Illinois has been printed, but awaits an appropriation by the

Legislature before the edition can be bound. A small number of copies have been bound and distributed.

THE SECOND ANNUAL MEETING of the Geological Society of America was held at Washington, Dec. 29–31. There was a large attendance, and numerous papers were read. The matter which was presented was so voluminous that it was necessary to divide the meeting into sections which were in session cotemporaneously. It is impracticable to present here even abstracts of the papers read, but as they may appear in the future publication of the bulletin of the society they will be further noted. In the absence of the president, Prof. J. D. Dana, and of the first vice-president, Prof. J. S. Newberry, both because of illness, the session was presided over by Prof. Alexander Winchell, the second vice-president. The meetings, which were continued forenoon, afternoon and evening of each day, were held in the Columbian University.

The following was reported as the result of the elections for 1891: *President*, Alexander Winchell, Ann Arbor, Mich.; *First vice-president*, G. K. Gilbert, Washington, D. C.; *Second vice-president*, T. C. Chamberlin, Madison, Wis.; *Secretary*, H. L. Fairchild, Rochester, N. Y.; *Treasurer*, H. S. Williams, Ithaca, N. Y.; *Councillors for one year*. J. C. Branner, Little Rock, Ark., Geo. M. Dawson, Ottawa, Ont.; *Councillors for two years*, E. W. Claypole, Akron, O., C. H. Hitchcock, Hanover, N. H.; *Councillors for three years*, I. C. White, Morgantown, W. Va., J. J. Stevenson, New York, N. Y.; *Editor*, W. J. McGee, Washington, D. C.

DIAMONDS HAVE BEEN FOUND recently in Wisconsin a few miles east of the Mississippi river, in the vicinity of Trempeleau. They were known to occur several years ago, but had not been brought to the notice of experts till recently, when they have been approved by Mr. Geo. F. Kunz, who read a paper on the subject at the late meeting of the Geological Society of America at Washington. They were discovered in washing gravel for gold, and seem to have been derived either from an outcrop of crystalline schists, or of a coarse conglomerate, which both occur near the spot.

THE

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REMARKS ON THE GEOLOGY OF THE CONCHO COUNTRY, STATE OF TEXAS.

By OTTO LERCH, M. A., Ph. D., San Angelo, Texas.

Since a joint publication by Prof. A. T. Cummins and myself entitled "A geological survey of the Concho country,"* I have studied the beds between the Lower Cretacic, the Trinity sands of Robt. T. Hill, and the Permian, which are well exposed a few miles west of San Angelo, near the center of that section of Texas. I am now inclined to think that this group of strata are of Triassic age, and may be a southward continuation and thinning out of the strata three hundred miles northward called Jura-Trias by Jules Marcou, the occurrence of which below the "staked plains" was announced many years ago by him.

Great denudation has laid bare several hundred feet of strata in vertical hight around the town of San Angelo. The waters of the Concho rivers follow the southeasterly dip of the Lower Cretacic formation and have cut through the chalky deposits of the Comanche series; their valleys gradually widen and after a comparatively short course of from forty to eighty miles, a number of these rivers and creeks unite a few miles west of San Angelo, where they cut down to sandy and clayey deposits with a north-westerly dip. This unconformity of the Red beds with the overlying siliceous strata below the Lower Cretacic, and the Red beds offering a stronger resistance have caused the waters to spread, and they have formed a beautiful and fertile valley from twenty to thirty miles in

*AMERICAN GEOLOGIST, June 1890. No. 6.

width which is still widening towards the east where they have uncovered the underlying Carbonic rocks. Back waters have cut deep channels into the retreating Cretacic, and especially prominent of these is the South Concho river with a length of about forty miles. The larger number of these rivers and creeks are fed by bold springs. Love creek, for instance, breaks from the Cretacic rocks, a ready stream not less than twenty feet wide by one and a-half feet in depth. The South Concho river and Spring creek have their sources in a number of springs of artesian character, located in the center of shallow basins of considerable size. That the deep and wide valleys of the Concho rivers cannot have been formed under the present climatic conditions but have been worn out by greater volumes of water, probably the inland sea which once covered the "staked plains," has been referred to in the paper mentioned above. R. T. Hill's "Staked Plain Series" covering the Cretacic of that western section of Texas, and consisting of beds of more recent origin, seems to prove conclusively the existence of such a sea in post-Cretacic times. Huge deposits of conglomerate composed of material derived from the adjacent Cretacic strata, accompanying the rivers and creeks along their course even after their confluence below the city of San Angelo for miles, and the lower dip of the underlying and adjoining deposits, appearing almost in a horizontal position, and which never have been disturbed by violent volcanic eruptions, speak of vast volumes of water which have broken the hard Lower Cretacic limestone deposits to fragments and have rolled the blocks before them, till, on reaching the older formations with their opposite dips and consequently increased resistance, they have slackened their swift current, grinding the material finer and spending their energy in widening their bed. The large fragments of conglomerate of cemented materials of every size, large blocks and

FIG. 1. *Profile through the Concho country.*
1. Lower Cretacic. 3. Permian.
2. Pre-Cretacic and Post Permian. 4. Carbonic.

small pebbles, the immense width of the valley of the main Concho river, the floor of which is the deposits of older formations with an opposite dip, the same level of the Lower Cretacic buttes and escarpments bounding the valley on either side, and the whole appearance of the country prove conclusively that it owes its topography to denudation, and that aerial currents had comparatively little to do with its present surface appearance. Such conglomerates as seen along the rivers of the Concho country often fifty feet high could only have been formed through the immense pressure of vast volumes of water in channels with little fall.

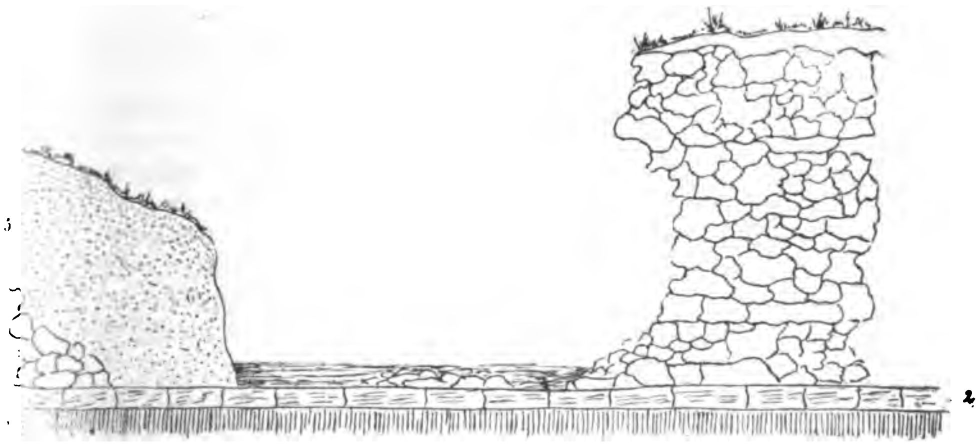


FIG. 2. *Profile of the North Concho river, ½ mile below San Angelo.*
1. Limestone conglomerate. 3. River silt.
2. Yellow magnesian limestone. 4. Red and blue clay.

As mentioned before this enormous denudation has laid bare the limestone deposits, clays and sandstones of every quality and color, representing various geological ages. Beginning in the western part of Tom Green county, the middle Concho river, having its source on the foot of the "staked plains" with an easterly course, crosses the different strata of the Comanche series, the probable Jura and Trias of Marcou, the Permian of Boll, Cope and others, and on reaching Concho county has uncovered the Carbonic rocks.

Near the top of the Permian exposed at Ben Fielin on the bank of the Middle Concho river lies a deposit of an argillaceous magnesian limestone of a yellowish color containing a number of well preserved fossils enumerated in the formerly mentioned article,

which leave no doubt that these and the strata below are of Permian origin.

Above this fossiliferous limestone rests a quartz conglomerate about twelve feet thick. The pebbles are well water-worn, of small size and bound with a siliceous and irony cement. The conglomerate is stratified, dips towards the northwest under a steeper angle, however, than the underlying Permian deposits, and is occasionally interspersed with large blocks of green and red speckled quartzyte. The conglomerate is very hard, takes an excellent polish and is of a yellowish-red color. Above it lies a series of red and yellow colored clays and sandstones about one hundred feet thick, overlaid by lighter buff and whitish colored thin beds of loose friable sandstone and clays about fifty feet thick, followed unconformably by the Trinity sands. I have called this complex of strata commencing with the quartz conglomerate and overlaid unconformably by the Trinity sand a southward thinning out of the Jura and Trias on account of its lithological character and stratigraphic position, not having been able to find fossils for confirmation. Along the Colorado river about thirty miles north of San Angelo gypsiferous strata are exposed above the beds described. R. T. Hill, in speaking of the Trinity sands, remarks :*

"The writer has made sufficient observations to prove beyond all doubt that they are newer than the gypsum-bearing beds of Texas and that there is a stratigraphic nonconformity between them, as seen at Sweetwater mountain, Nolan county, Texas, and at Tucumcari mountain......In general lithological appearance and in occurrence of saurian remains, these beds bear striking resemblance to the Atlantosaurus beds of Canyon City, Colorado, and Como, Wyoming." It has been justly remarked that the stratigraphic position of a series of beds even when different in lithological character from the underlying and overlying deposits alone does not prove their age and so long as there are no fossils found and described the age of the enumerated strata may not be considered conclusively determined. However, this characteristic conglomerate indicates a total change in the topography of this section at the close of the Permian, and doubtless has been formed by strong currents along a coast line. The quartz pebbles constituting it, though small and well water-worn, still enclose large blocks

*Arkansas Geological survey. Annual Report, vol. ii, 1888, p. 125.

of quartzyte, remnants of the original material from which it has been derived. I have traced this conglomerate for nearly twenty miles toward the north and its stratigraphic position with the beds above, below the Trinity sands, and Hill's notice indicate an immense extension and uniform conditions existing at a time when probably after a long period of land a new submergence of this section of western Texas took place, or rather, frequent though slow and gradual oscillations were changing its character from a sandy beach to a muddy sea and again reversing the process of submersion and emersion. As these beds are lithologically so different from the strata above and below and as they are unconformably overlaid and underlaid by the lower Cretacic and Permian I feel justified in considering them pre-Cretacic and post-Permian, and probably they may be the continuation and southward thinning out of the Jura and Trias, and propose for them the name of the San Angelo beds.

RECENT EARTHQUAKES IN NICARAGUA.

By J. Crawford, Managua, Nicaragua.

A number of earthquakes, some of them quite severe, were felt in and near the city of Granada, Nicaragua, commencing 31st ultimo, (Aug. 31st, 1890,) at 10 :30 o'clock A. M., and occurring at intervals, of half an hour to three hours until the morning of the 3rd instant, then occurring at intervals of from 24 to 36 hours until the 22d instant.

On the 3d instant. I was requested by Dr. Don Roberto Sacasa, president of the republic of Nicaragua, to visit the earthquake locality and examine and report on the phenomena, depth and form of focus, epicentrum, angle of emergence, amount of oscillation, direction and velocity of transit, probability of recurrence, etc. The investigation was commenced in the city of Granada, on the afternoon of the 3d instant. The city was nearly depopulated by the flight of its inhabitants, no lives were lost, no person received serious bodily injuries, although near that city the horizontal inclination of the waves from a perpendicular (half the angle of oscillation) was about 23°, 17′. A few old adobe houses with tile roofs were partly destroyed and many tile roof

houses with good abobe walls were cracked and otherwise injured. About 400 infantry, mounted and on foot, were patrolling the streets and guarding the property of the absent citizens. None of the professors in the "Institute Nacional de Oriente," nor in any private schools in that city, so far as I was able to learn, had made notes of the phenomena, nor improvised any seismological meters, nor motors, neither noted the seconds of time of occurrence of any of the waves of force, nor the temperature or atmospheric pressure (two or three doctors of medicine made notes of the minute of occurrence of some of the earthquakes and their probable direction of transit). The clocks and watches in that city are not, generally, regulated to correspond with any one chronometer. The foregoing will explain the frequent use of the word "about" in place of a definite expression in the following.

The city of Granada is situated in a Miocene and Pliocene volcanic formation, on the west side of lake Nicaragua, about 30 miles east from the Pacific ocean; the deepest ravines and craters of volcanoes and wells (600 feet deep) present uncompacted rhyolite, trachyte, andesite, phonolite, basalt, pumice, scoriæ, sanidin, and other forms of igneous and aqueo-igneous volcanic materials: about three miles south and southeast from the city is the northern foot line of the Tertiary part of the Cenozoic area. Volcano MOMBACHO and its numerous variously shaped monticules, also situated on the west side of lake Nicaragua, all together have a base of about twelve miles in diameter. About four leagues to the southeast of MOMBACHO is the equally large mass of volcanic materials, erupted in Tertiary times, named volcano ZAPETERA and forming a peninsula in the lake; about six leagues to the southeast of ZAPETERA, in lake Nicaragua, is the large island which was formed by the now inactive volcanoes OMETEPE and MADERA that originated in the Quaternary epoch; far to the southeastward (30 to 40 leagues) is the COSTA RICA group of smoldering, inactive and possibly some extinct volcanoes, originating in Tertiary times and continuing into the RECENT epoch. These, Madera, Omatepe, Mombacho, with Masaya, Mometomba (6,400 feet high) and a few other inactive and extinct volcanic masses in Nicaragua, form the links in the chain which connected the San Salvador and the Costa Rica groups of volcanoes. Enormous quantities of the loose material, from all the volcanoes in San Salvador, south

western part of Honduras, and the northwestern part of Nicaragua, since the formation of these volcanoes have been swept by torrents and rivers into the Pacific ocean, along and near to the western coast of Nicaragua, and this is still going on. These materials have formed there an extensive deposit probably more than 20,000 feet deep. These facts account for, or are in some way connected with, the apparently complete removal from the former active volcanic region in Nicaragua, of the hydro-thermal forces which were once largely influential in causing and continuing volcanic activity and earthquakes in that region.

Some of the phenomena noted by me were local, the surface waves of force not extending over an area of more than 30 miles in diameter, or if beyond that not sufficiently perceptible to be worthy of note. The waves along whose very irregularly curved line of transit the greatest disturbance was observed were about three miles (semi-diameter, the other half of the diameter was in lake Nicaragua) southeast, south and southwest of the city of Granada; along on the side, near the foot of the large, ugly volcanic mass, MOMBACHO, at lake Apoyo (situated in a crescent-shaped crater one-half mile wide and one mile long and 300 feet deep) Haciendas Carmen and Fuentas, Monticule Pilon, Haciendas Agosto and La Hoyo; thence eastward into lake Nicaragua. The city of Granada was outside of the circle of greatest disturbance. The focus was beneath lake Nicaragua a few miles north of the inactive volcano OMETEPE about 15° east from south of the city of Granada, and extended westward. The oscillation of the severest wave felt in Granada was fully 11°, 47′, from a perpendicular, and sufficient to cause a bell, *fixed* about sixty feet above the surface of the street, in a tower at the northeast corner of Anglesia Merced, to incline and strike the iron clapper suspended in it and sound out loudly three protracted notes. (This, 11°, 47′, was one half the angle the bell would have to pass through to strike the clapper, but it is adopted because the clapper was so attached to the bell as not to be perfectly free to retain its perpendicular position when the bell was inclined.)*

If the clapper had been free to retain a perpendicular position

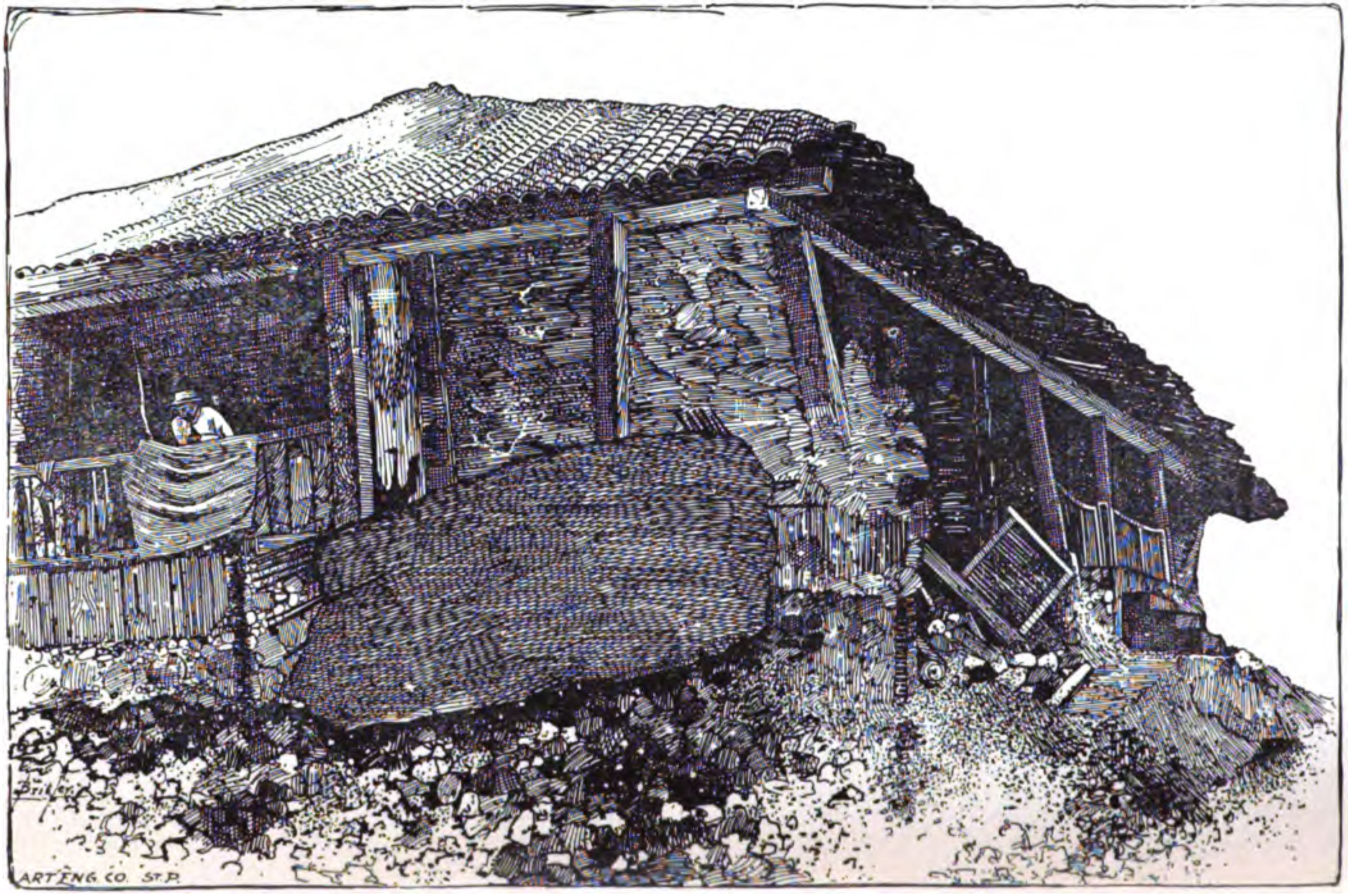
*I made several trials inclining a similar bell (free, not fixed, in a tower), having a similar clapper and attachment; the clapper always inclined with the bell 8° to 10°, before swinging loose and returning to a perpendicular position.

and in the center of the bell, then the latter would have had to incline about 23°, 17′, to have struck the former with sufficient force to have produced loud sounds.

The diameter of the surface waves where the horizontal element was sufficient to be noted, was about 30 miles. The focus was about 6,900 yards deep below the earth's surface; this was calculated from the curved seismal line extending through the places where the force at the surface was noticed to have been greatest, and from the probability that the diameter of the surface waves there, where the horizontal inclination was at greatest angle with the declining oscillation and the focus, was the base of a cone whose apical angle was 70°, 32′. The strongest wave extended for about 30 miles into the Pacific ocean; a few others extended about 20 miles, and several only nine to twelve miles from Monticule Pilon on the line of greatest disturbance.

The velocity of transit of the spherical waves through the not firmly compacted volcanic formation was about 6,000 feet per second. This was ascertained by three fortunate experiments, in similar materials between two stations 9,556 feet distant from each other and about 200 feet deep in volcanic craters. The velocity of the surface waves was much greater than that of the spherical waves. I could not get reliable information. The telegraph operators at the stations, Granada and Masaya, 12 miles from each other on the railroad between lakes Nicaragua and Managua, were not sufficiently active, and the clocks did not correspond; but it was about *10,000* feet per second.

The moon was about Syzygies; the season of the year, winter or rainy season, but unusually dry from lake Nicaragua to the Pacific ocean; no corn, grasses or vegetables had produced crops this season in the western third of Nicaragua. The remaining two-thirds of the country had an abundance of rain at this season of the year, as usual. In Managua, church bells were tolled and prayers for rain were offered. The larger number of the earthquakes were felt during strong currents of wind. No unusual meterological phenomena were observed between the 3d and 12th inst., although several earthquakes were experienced between those dates in the locality of the city of Granada. "Hazy, murky, atmospheric condition prognosticating earthquakes"—I have frequently and anxiously looked for such a condition of the atmos-



Hacienda Fuentas, after the earthquakes.

phere to be followed by earthquakes but always have been agreeably disappointed in this and in other countries when studying earthquake phenomena. It is full time, I believe, to expunge such unsustained statements from our climatic and seismological literature. Since the commencement of the earthquakes, domestic animals such as cows, horses, etc., were noticed to graze all day near the houses and not go out as usual, far into the postraros for grass ; also wild animals, as the deer (Cervus nicaraguensis), came out from their usual places, the ravines and woods on the sides and near the top of the extinct volcanic mass Mombacho, and were found in numbers herding with and hiding near the cows, near the houses or residences on the haciendas.

The motion felt during the first six days as described by nearly all persons, was, *at first, jarring*, as if the earth on which they stood had suddenly dropped down and come in contact with a solid portion ; then the motion during the remainder of the shock was *undulating* as if the earth beneath them was sliding from place to place against other parts of the earth in an effort to become permanently adjusted. The sound which preceded and accompanied the first motion during the first few days, was a grating, grinding noise, rumbling like the sound of heavily loaded cart wheels over cobble paved streets. After the 5th or 7th instant, the sounds, motions (and causes) of the waves were very different from those above described; the motion was that of true horizontally inclined progressive waves, and the sound was rough, gurgling, bubbling, as if of water at 212° Fah., or greater temperature. The first waves were elicited by the sudden shrinkage of the geological formations, and often repeated efforts to attain equilibrium between the friction and gravity at some point where the loss of heat had been much more rapid toward the interior than at the surface ; and the frequent recurrence of the shocks for several days until the 7th instant, was, I am persuaded, from considering all the phenomena, *mechanical energy*, causing change of position and form, and readjusting and compacting of the volcanic materials. There are many reasons to believe that the formations, from surface to focus, and even deeper in that locality, are composed of loosely compacted materials with many cavernous places, rendering contraction and sudden shrinkage probable occurrences. The mechanical energy also, I believe, occasioned a

few small, irregular fissures, near the shrunken and compacted materials extending from the focus or near it, up to the bottom of lake Nicaragua, through which water circulated. These waters found access to a temperature of about 400 Fah., and generated aqueous vapors until their elastic force was sufficient, assisted most probably by other gases of greater elasticity, to cause the earthquakes and the sounds associated with them, from the 6th to the 22d instant. There were no indications observed of vortical motions, nor of that class of earthquakes. Neither was there any of the bounding or tossing up movement, nor deafening sounds of the explosive type of earthquakes. If the water from lake Nicaragua found access to the geothermal plane where the focus of the first earthquake was found to be, it is reasonable to conclude that this is the process by which are formed caverns containing liquid rock materials and elastic gases and aqueous vapors; and that these will increase in size, quantity and elastic force, until sufficient force has accumulated to upheave and eject the superimposed masses, in other words, commence volcanic activity, like volcano Tarawara in New Zealand; this activity once originated will continue so long as lake Nicaragua, like the lake once existing near volcano Tarawara, previous to the eruption of that volcano, supplies the water necessary for its promotion. Strong alkaline waters at 400° Fah., in long contact under a pressure of 3 or 4 miles of superimposed material will, no doubt, dissolve all kinds of rocks, and the dissolved material will occupy much less space than when in a loosely compacted condition. Consequently the caverns that are formed are constantly increasing in size. allowing for a constant increase of the materials that promote volcanic energy. But earthquakes appear to have ceased in that locality, perhaps because the fissures have been closed by shrinkage or filled with pozzuolano or other hydraulic cement.

The facts observed during the recent earthquakes assist in establishing the following in reference to this class of physical phenomena.

1st. They frequently are the result of sudden shrinkage from greater contraction in the interior along certain radii than at the surface—Mechanical energy.

2nd. They may and often do originate locally a few miles only

beneath the earth's surface, and give no indications from which a liquid condition of the interior of the earth could be supposed.

3rd. They may be local on the earth's surface, and do generally cease when the causes (contraction, shrinkage, etc.), have ceased.

4th. The "waves" of force in earthquakes are sometimes both *low* and *rapid.*

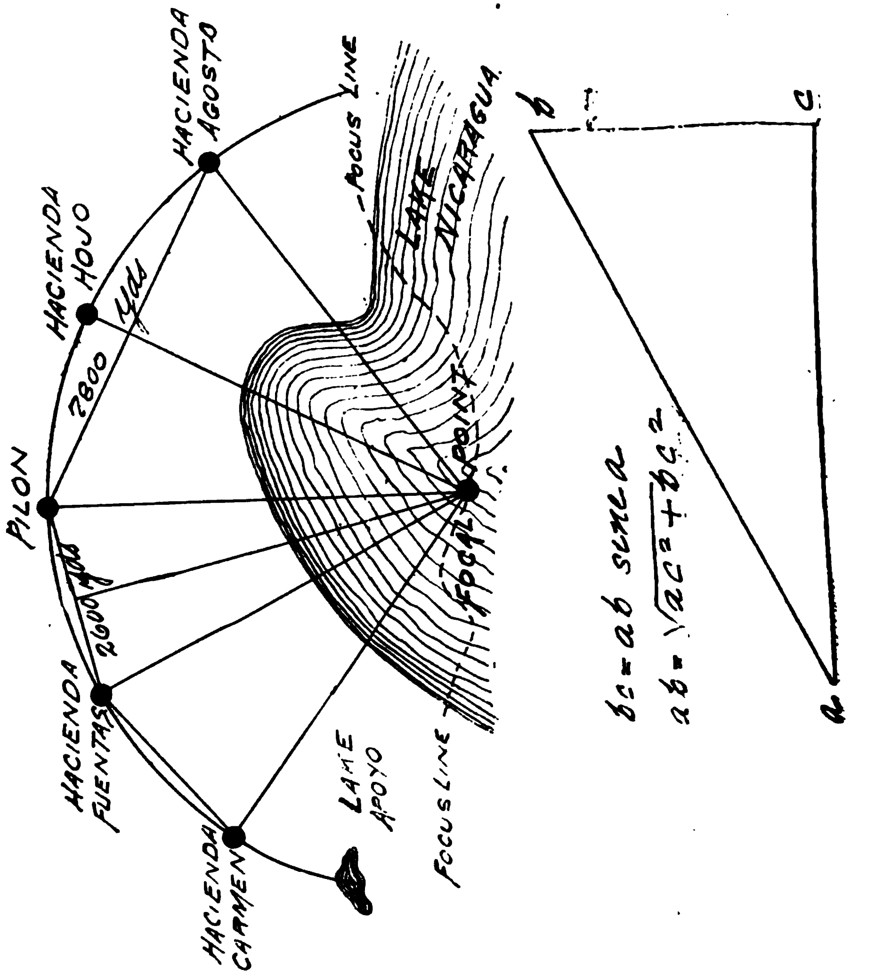
5th. When caused by contraction and sudden shrinkage they produce a more consolidated condition of the formation, from the surface to the focus.

6th. At the same time they may cause fissures about the focus and originate caverns partly filled with liquid volcanic rock or with elastic gases and vapors, and these may become the primary reservoirs for volcanic materials and forces, from which in course of time may be ejected lava and vapors and cinders.

7th. It is possible that the liquefaction of rocks and formation of elastic vapors and gases may cease before the forces are sufficiently strong to result in volcanoes, because of the closing by some natural cementing process of all the fissures through which alkaline waters can find access to the heated interior.

The difficulties attending the study of earthquake phenomena during the exciting times which they cause are numerous, various and great; after they have ceased it is almost impossible to obtain reliable information about them even from those persons who are, in other circumstances, usually calm and observing. To portray some of the difficulties, I relate the following, a part of my recent experience: Early in the evening of the 5th instant, my party (consisting of four intelligent gentlemen, myself and two servants) arrived to remain all night, at Hacienda Fuentas, situated on the line where the greatest disturbance had been observed; night had fallen and a dark rain-cloud was rapidly approaching. The dwelling house was an L shaped, tile roofed, building with adobe walls, of which the south and west walls had fallen during an earthquake on the 1st instant, and the roof on those sides was supported by posts (See plate II). The tiles on the roof had been disarranged in many places or thrown from the roof; to the north was a smooth "patio" or yard about 100 feet square; all, house and yard, occupied the top of a knoll of volcanic materials. The "major domo" or superintendent and several men living (in great

fear) on that estate declared to us that the yard was "*full of fissures*, whose open mouths had been closed by sweeping dirt, etc., into them." The darkness was too intense, and our lamplight too feeble in the wind to permit us to see distinctly that night. The



relators knew that they were telling us a *falsehood* which we would certainly detect the next morning and that they might be severely punished for attempting to misinform us. They were not trying to frighten us, neither to portray in false colors the

disastrous condition of the premises. They were counting beads on rosaries and saying prayers most of the time, yet there were no fissures, not even a superficial one, in or near that yard. The next morning they declared to us that they had witnessed "the ground open in several places in the yard during the severe earthquake on Monday of 1st instant, and supposed the openings had closed," and that "the boys had covered the tracks over with dirt when sweeping the yard." They honestly believed that they had seen the ground open during an earthquake. There is a popular belief afloat in countries where earthquakes are felt, that during a severe earthquake, the earth is seen at various places to *open into numerous fissures then close again*, without leaving any other evidence of a rupture than the false and frightened relator. While at the Hacienda Fuentas, about 7 o'clock P. M., there arrived during the rain, nearly exhausted and much frightened, a man, woman and two children, and stated that about one-half hour previous, and about one mile distant, they were under a tree near their house, near the foot and north of Monticlue Pilon, when they felt a severe earthquake, and witnessed a fissure open in the earth over three feet wide and extending many feet into the woods. We had felt that shock; it was not remarkably severe, but the fissures were not found, although the man and woman faithfully assisted us the next day in our attempt to find them. That part of their story was false, although they fingered the beads on their rosaries as they persisted next day in declaring that they had witnessed "the ground near them open during the earthquake" and they marked out for me the exact place, and they believed that they were telling the truth. None of these relators were stupid; on the contrary they were intelligent enough to make money and live with the comforts usual to that locality. These are fair examples from a mass of statements made to us by different persons, and they correspond with tales told me during the examination of earthquake phenomena in other countries. Unquestionably there is much difficulty during and immediately succeeding severe earthquakes, in commanding the mental faculties so as to keep them in a condition suitable for cool, critical observations. I have had voluntary experience several times in severe earthquakes, and in long contested battles where several thousands of men were engaged in deadly contest. In battle there is to sustain one, a conscious-

ness of being in the right, memory of loved ones at home, gallantry of companions, hope of victory, pride, ambition, etc., but in a severe earthquake there is experienced an absolute isolation and consciousness of the inability of any person or thing to assist, or to help out of the difficulty; as you move your foot forward and downard, for a secure resting place, it goes on, down and down, until suddenly and roughly arrested by a strong, unseen, approaching force; as the eyes look out for information they see everything in a disturbed condition, apparently hopeless and in helpless attitudes. Therefore, earthquake phenomena are difficult to study; stoical persons observe only what their previously determined opinions dictate, and nervous people see mythical wonders innumerable and indescribable.

There accompanied me during the many days we were engaged in the examination herein related, at my request, Prof. Senor Don Alberto Gamez, Physical Science and Chemistry, Instituto Nacional de Oriente, Granada; Prof. Santiago Ordozgoite, Mathematics, Institute Nacional de Oriente, Granada; also Mr. S. H. Young, of Philadelphia, Pa., resident in Granada, whose knowledge of the country roads, acquaintance with people in the Haciendas, and quick observation and practical way of criticising what we saw and heard, were of great assistance to us: also, Mr. I. L. Sullivan, of Philadelphia, Pa., resident in Granada, an educated mechanical engineer familiar with mechanical laws and forces. His observations and photographs and diagrams were of much assistance.

Managua, Nicaragua, Sept. 27, 1890.

ORIGIN OF THE BASINS OF THE GREAT LAKES OF AMERICA.*

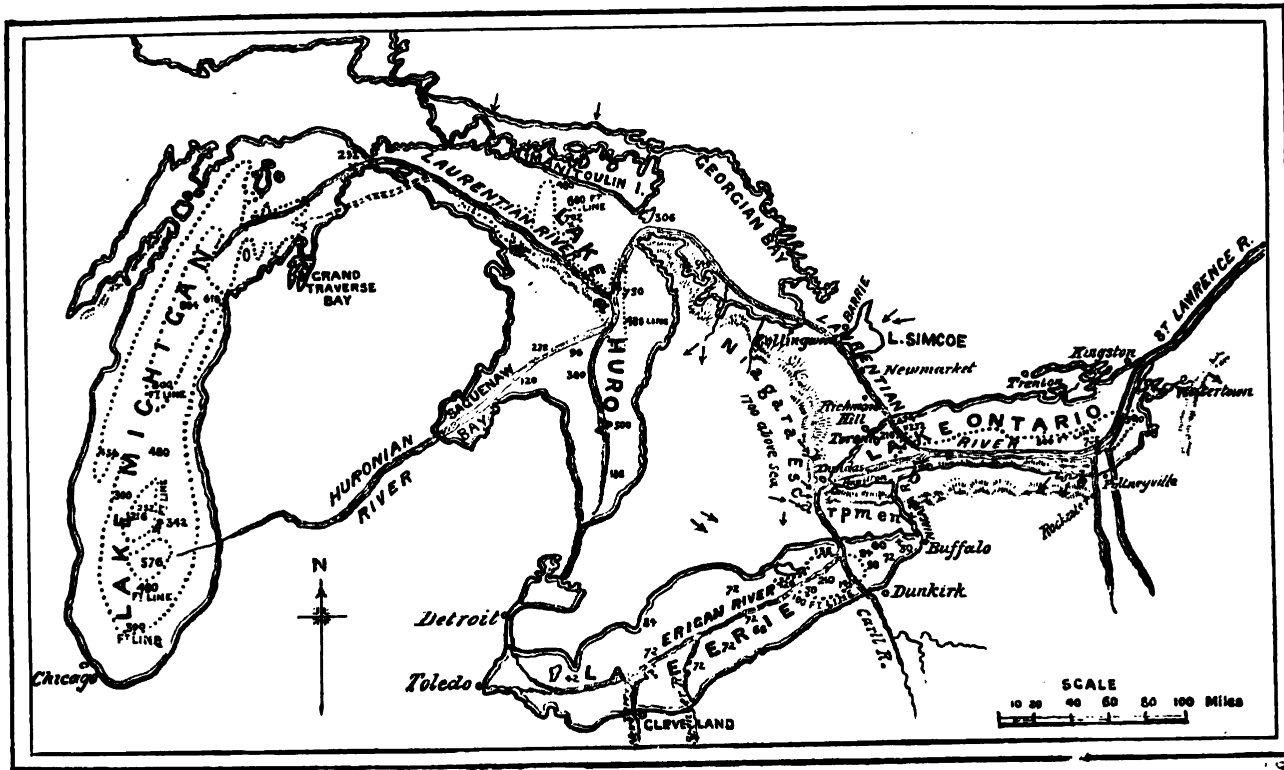
By J. W. Spencer, M. A., Ph. D., F. G. S., Atlanta.

Contents.

1. *Introduction.*

Even as recent as a decade ago very little was known as to the origin of the great lakes of North America. Whilst we find such generalized statements as "most lakes are due to terrestrial crust-

*From the Quarterly Journal of the Geological Society, Nov. 1890, Vol. XLVI.



Map of the ancient river-system of the basin of the great lakes.

movements," yet such crust-movements had not been tested in the American lake-region. Again, from the time of early geological investigations in America, statements are found that the basins were the result of erosion; but the methods of erosion were not explained, and this was the more necessary as most of the basins have rock-bound outlets. Later in some geological literature, the method of excavation was hypothetically attributed to glaciers. Such was the unsatisfactory condition of our knowledge of the problem when the writer first commenced the study, in attempting to solve the origin of the Dundas valley, at the western end of lake Ontario, more than a dozen years ago. This investigation has developed results bearing not only upon the origin of the lake-basins, but also upon the physical history of the lakes, and broader questions of the building and sculpturing of the continent.

The methods of investigation have been the studying—(1) of the hydrography of the modern lake-basins and submerged channels upon the coast of America: (2) of the deep wells bored into, or through, the drift Deposits, by which buried channels, and their relation to or contrast with the modern valleys, have been discovered; (3) of the elevation of the continent; (4) of the direction of the glaciation in the lake-region; and (5) of the now high-level beaches, in which are recorded continental uplifts, together with the deformation of the old surfaces, owing to unequal terrestrial movements or warpings of the earth's crust*. The lakes which have been the basis of the more careful investigation are Ontario, Erie, Huron, and Michigan, with the respective altitudes of 247, 573, and, of the last two, 582 feet above the sea (see the map p. 87.)

2. *Features of the Ontario basin.*

Lake Ontario, as was shown in an earlier publication†, is a basin bounded on its southern side by escarpments, often precipitous, of which some of the steps are now submerged. At the foot of the submerged escarpments a valley like that of an ancient river may be recognized from the western part of the lake to near the eastern end, but there it disappears, for reasons to be noted later.

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*In the field-work I here acknowledge the assistance of professors D. F. H. Wilkins, W. W. Clendenin, and W. J. Spillman.

†"Discovery of the preglacial Outlet of the Basin of Lake Erie into that of Lake Ontario," by J. W. Spencer; Proc. Am. Phil. Soc., Philad. 1881.

The deepest part of this valley is 738 feet beneath the surface of the lake. From this trough the floor of the lake rises gradually, or with occasional low steps, to the northern shore. In short, the basin was once an old land-valley traversed by a river. At the western end of the lake borings have revealed an old channel, having a lateral depth of 292 feet. This is the continuation of the *canon* of the Dundas valley, which is about two and a half miles wide, bounded by rocky walls nearly 500 feet high, capped with Niagara limestone. Down this valley the waters of the ancient Erie basin once flowed*.

If the waters of lake Ontario were withdrawn, its present basin would be a broad valley, continuous with that of the St. Lawrence valley, having a breadth of thirty or forty miles. Into this plain, at a point about twenty miles east of Toronto, there is a channel, approaching the shore, whose bed is 474 feet below the surface of the lake†, but with boundaries submerged to only 200 feet. This depression trends southward and joins that at the foot of the submerged escarpment before mentioned‡.

3. *Features of the Erie basin.*

The floor of lake Erie is a broad flat plain, now rarely submerged to a depth of more than 84 feet, and usually less. Only a small area, situated directly south of the western end of lake Ontario, is of greater depth, and there the greatest sounding is 210 feet§. But from this region the Erie valley was drained by the Grand river and Dundas valleys into the western end of lake Ontario, as was shown in 1881; for the Niagara river did not then exist. Numerous tributaries of the modern shallow lake flow over deeply buried channels, the deepest of those discovered being 228 feet below the lake-surface, as described by Dr. Newberry‖, although the floor of that portion of the lake is nowhere over 84 feet below the surface of the water.

Similar channels, buried to depths below the floor of the eastern end of lake Erie, near Buffalo, have been described by Dr. Julius Pohlmann¶. The borings into many others in the region

*See "Discovery of the Preglacial Outlet of lake Erie," etc.
†See British Admiralty chart of lake Ontario.
‡See U. S. Lake-Survey charts of lake Ontario.
§See U. S. Lake-Survey chart of lake Erie.
‖Geology of Ohio.
¶Paper read before the Amer. Assoc. Advanc. Science, 1883.

of the western end of the lake have been recorded by Prof. T. Sterry Hunt*, and prove the existence of similar buried channels.

The original recognition† of the valley-like character of the basins of Ontario and Erie was based upon the above-mentioned characters, and upon others now supplemented by a more perfect collection of facts; but the greatest difficulty was in the occurrence of the rock-bound outlet of lake Ontario, a difficulty which observations have at last dispelled, as will be seen later on.

4. *Features of the Huron basin.*

The southern half of lake Huron is a plain traversed by valleys and submerged to form only a shallow lake. Northward of this shallow basin, and extending obliquely across the lake for ninety miles, there is a submerged escarpment rising to a hight of from 300 to 450 feet, facing north-eastward. The deeper part of the lake then trends northward in the direction of Georgian bay. At one point the extreme depth of the submerged valley reaches 750 feet. The absolute depth of the rock in the deepest channel between lake Huron proper and Georgian bay is not known, but soundings show 306 feet; and as there is a deep channel upon the western side of Georgian bay it becomes highly probable that a deeper and connecting channel is filled with Drift, like those known to occur elsewhere, beneath the lakes. From the straits, between the islands, the narrow channel in Georgian bay, just referred to, extends south-eastward and is submerged to a depth of 510 feet. This is at the foot of the Niagara escarpment, which extends, as a strong topographic feature, from the head of lake Ontario, and, rising in places to 1,700 feet above the sea, into the peninsula between Georgian bay and lake Huron proper. The channels at the foot of escarpments, submerged or otherwise, in lake Huron and Georgian bay are fragmentary records of the history of the lake valleys‡.

5. *Features of lake Michigan.*

This lake is divided into two basins. The more northern and larger basin has a maximum depth of 864 feet. It is, in part, bounded by vertical submerged escarpments, one of which, upon

*See Report Geol. Canada, 1863-66.

†See "Discovery of the Preglacial Outlet of lake Erie," etc.

‡See U. S. Lake-Survey chart of lake Huron, and the Canadian chart of Georgian bay.

the eastern side, has a hight of 500 feet. Whilst the deepest sounding at the modern outlet of the lake is only 252 feet, there are adjacent channels buried to unknown depths. But these have been imperfectly explored. Into this shallower portion of the lake, however, the fjord of Grand Traverse bay has a northernly trend; it is 612 feet deep. This and the lesser fjords indicate the existence somewhere of a deep channel connecting with the Huron basin, as much as the river-valleys buried beneath the Drift materials of the modern floor of lake Erie prove deep channels throughout that basin, although not shown by the soundings; for the lake Michigan valley is carved out of undisturbed and almost horizontal Palæozoic rocks, the newest of which are Coal-Measures.

The southern basin of lake Michigan is separated from the northern by a plateau submerged to a depth of from 300 to 342; whilst the southern basin itself is now 576 feet deep. The area of this portion of the basin is now much smaller than that of the pre-Pleistocene valley, as its margins have been filled with Drift, and now form broad plains bounding the lake. Beneath these deposits is a deeply buried channel, leading to the valley of lake Huron, and to be noted further on.

6. *Buried valleys revealed by borings.*

The deep wells revealed the existence of the buried channel down which the waters of the Erie valley originally drained, and thus established the relationship of the Erie with the Ontario basin. But the most important series of borings were those between Georgian bay and lake Ontario, for here we have the connecting-link between the valleys of the upper lakes and that of lake Ontario, and indeed the key to the origin of the valleys of the lakes.

Between Georgian bay and lake Ontario, a distance of about 95 miles, a portion of the country is comparatively flat or composed of a series of rising plains; but there are also high transverse ridges of Drift, having a general trend of east and west. It is upon the northern side of the Drift ridges that lake Simcoe, with a diameter of about twenty miles, is situated. But upon the northern side of lake Simcoe there is another series of Drift ridges trending towards the north-east. Both of these series of ridges

rise to between 200 and 550 feet above lake Huron, these measurements being the extreme variation in their hight.

From Georgian bay to near lake Simcoe, for a distance of thirty miles, the country is low and flat, with a known absence of rock to far below the level of the bay. Lake Simcoe is 140 feet above Georgian bay, but upon its northern side, at Barrie, a well has been sunk in the Drift, without penetrating it, to a depth of 280 feet below its surface. Thirty miles further inland, south of lake Simcoe, at Newmarket, a well was in the process of being bored. It had reached a level below Georgian bay and was yet in Drift deposits when visited. In another well, several miles to the westward, near the side of the ancient buried valley at Beeton, rock was reached at 50 feet below the surface of Georgian bay.

Between Newmarket and Richmond Hill there are several deep wells on the heavy Drift ridges which cross the country. But at Richmond Hill, at a hight of 217 feet above Georgian bay, there is a well 400 feet deep without penetrating the Drift. This proves the thickness of the Drift of the higher ridges crossing the old valley north of the well to be not less than 700 feet in the old channel. Southward of Richmond Hill the country falls away in a series of more or less rolling steppes to lake Ontario, but these plains show the absence of rock along deeply-cut valleys to far below the level of the upper lakes. Upon the western side of this chain of borings, but a few miles distant, there is the Niagara escarpment. Upon the eastern side of lake Simcoe the country is covered with flat limestones, rising to 150 feet above that lake. From the known absence of rocks along the line of borings and stream excavations, between a high mountainous escarpment upon one side and a rocky floor upon the other, and from these borings reaching to 200 feet or more below the upper lakes, without penetrating the Drift but stopping in quicksand, there has been discovered the existence of the only channel of antiquity which could now draw off the waters of the upper lakes, if the Drift were removed. Although none of the borings have reached the original rocky floor, yet the depth of the buried valley is suggested by the channel close upon the northern side of lake Ontario, now submerged to 474 feet, which is deep enough to drain the last drop of water out of lake Huron.

We have now found one continuous channel from lake Michigan

through lake Huron and Georgian bay, and thence buried beneath Drift deposits until it is again recognizable throughout nearly the whole length of lake Ontario, being joined at the western portion by an ancient outlet of the Erie valley (the ancient *Erigan* river). But the relative maximum depression of the channels, as far as explored, is disturbed by terrestrial warpings to be described hereafter.

Across the southern part of the peninsula of Michigan, between hills rising upon either side to hights of sometimes 800 or 1,000 feet above lake Huron or lake Michigan, there is a valley whose western portion is occupied by the Grand river, and the eastern by a small river emptying into Saginaw bay. At the divide between these rivers the land does not exceed 100 feet above the lakes. The topographic features of the valley show its original opening as having been into the Huron valley by Saginaw bay; but a considerable proportion of the modern drainage is in a direction opposite to that of the valley, or flowing towards lake Michigan—that is, the drainage has been reversed. The maximum depth of the western portion of this buried valley is not known, but there is an absence of rock, as shown in several borings, to between 100 and 200 feet below the lake-level. But farther east in this trough there are several deep wells, in one of which the Drift is 500 feet below the floor of the side of the valley, or 350 feet below the surface of lake Huron*. Hence we have established the great depth of the buried valley between the southern part of lake Michigan and lake Huron, whose ancient river I name the *Huronian*.

Other buried valleys and channels submerged could be given, but they all indicate the origin of the basins of the lakes as the valleys of a great river and its tributaries—a river of such high antiquity that the rains and rills had already ground off the surrounding hills to broaden the valleys. But for all this evidence, there are now rocky barriers forming an apparent obstacle in the way of a complete solution of the problem.

7. *The Glaciation of the region.*

At the present stage in the investigation this subject can be quickly dismissed. The question whether glaciers can erode great

*This is at the Sanitarian well at Alma, Mich., the record being furnished by Prof. Charles A. Davis.

what are the maximum soundings in the river, yet the old channels are so filled with Drift that their depths are not revealed. Still, we know that in one portion of the channel cut out of limestone and more or less filled with Drift, the sounding is 120 feet. A short distance beyond, the channel across the Laurentian gneisses shows soundings of 240 feet. The maximum depth of the lake-basin is 738 feet. The deformation recorded in the beaches is more recent than the episode of the upper till. Consequently, if the continent were at a high level, with the warping, known to have occurred since the Drift was deposited, removed, as shown by the above figures, there would be not only no barrier, but a sufficient slope in the Laurentian valley for the drainage of what is now the Ontario basin.

Furthermore, the presence of the rock barriers of the rapids of the St. Lawrence, further east, are wholly accounted for by the terrestrial warpings of the region. Hence, I have demonstrated, after a decade of study, that no barrier existed across the Ontario valley when it was being carved out by the ancient St. Lawrence, and that this barrier is of quite modern origin.

South-east of Georgian bay the average measured warping is four feet per mile, in mean direction of N. 20° E. This will account for a portion of the barrier closing the Georgian outlet of lake Huron. The more elevated beaches in the region of lake Huron record a still greater change of level.

At the outlet of lake Erie, Mr. Gilbert and myself find a differential uplift of about two feet per mile, and this is sufficient to account for the recently formed basin of lake Erie.

The warping affecting the Michigan basin has been that towards the north and east; and even in the buried channels south of lake Michigan there is no evidence of an ancient drainage to the south, as their beds were too high compared with those of the northern. although the latter have been elevated recently by warping.

10. *Conclusions from the observations.*

The valleys of the great lakes here studied are the result of the erosion of the land-surfaces by the ancient St. Lawrence (named *Laurentian*) river and its tributaries, during the long period of continental elevation, until the streams had reached their base-lines of erosion, and the meteoric agents had broadened the val-

leys. This condition was at the maximum just before the Pleisto cene period.

The closing of portions of the old Laurentian valley into water-basins occurred during and particularly at the close of the Pleistocene period, owing, in part, to Drift filling some portions of the original valley, but more especially to terrestrial warpings of the earth's crust, which, to a sufficient degree, is measureable.

THE AGE OF THE CINCINNATI ANTICLINAL.

BY AUG. F. FOERSTE, Cambridge, Mass.

Exposures of Cincinnati group formations in southwestern Ohio, even when of considerable length, show a striking horizontal disposition of strata. Only when outcrops from distant localities are compared can their connection with the Cincinnati anticlinal axis be recognized. By many this axis is believed to have advanced beyond incipient stages of formation, if not to have attained complete development, in Lower Silurian times. Even ripple marks, mud cracks and rain drop impressions are cited from the Cincinnati group rocks of anticlinal regions, in support of contemporaneous shallow water conditions. Accepting the validity of this evidence for the present, how does this prove that shallow water conditions, thus inferred, were caused by the presence of the Cincinnati anticlinal axis, and were not also prevalent in neighboring regions now forming the lower flanks of the axis. Until ripple marks, mud cracks and rain drop impressions can be shown to characterize the axial, more elevated regions of the anticlinal, and to be absent from its less elevated flanks, no such wide and general deductions can be made with safety.

Consistent with the view which places the incipient or even the final development of the Cincinnati anticlinal axis in Lower Silurian times, later strata of Upper Silurian, Devonian and Carboniferous age, are believed to have been deposited, with this anticlinal axis as their core, and its debris as the source of the materials necessary to their formation. As evidence of such a relation a conglomerate is cited already from the base of the Upper Silurian formations surrounding this axis, in the Clinton

group west of Belfast, Highland county, Ohio. Specimens collected by Prof. Edward Orton, and kindly loaned to me by Prof. John S. Newberry, show the cement between the pebbles to be abundantly supplied with fossils. A dozen species were recognized. One of these, *Stictopora similis Hall*, has hitherto been described only from the Niagara group of Indiana. The remainder are all well known Clinton forms. Among these are *Cyclonema bilix* Conrad, *Orthis biforata* Schlotheim and *Strophomena rhomboidalis* Wahlenberg, the easily recognized Clinton forms of species also occurring in Lower Silurian strata along this anticlinal axis. The *Orthis* has two plications in the mesial sinus instead of three as commonly the case in related representative Lower Silurian types in this region. All remaining forms are characteristic Clinton species, not represented by close allies in Lower Silurian strata. The Clinton age of the conglomerate is therefore undoubted. The pebbles however are unfossiliferous; their age could therefore not be determined. Still less is it possible to designate their source. That they were derived from debris arising from subaërial parts of the Cincinnati anticlinal axis is purely conjectural. Their source may have been in exactly the opposite direction; it is unknown. The lithological character of the pebbles does not demand even an original association with Cincinnati group rocks, since there is nothing very distinctive in the mere fact that the pebbles are formed of a bluish limestone.

The pebbles are drab-blue in color, with the exception of one pebble with dirty white or brownish white tints. The largest seen was two and a half inches long with nearly the same breadth, and a quarter of an inch in thickness. From this size they dwindle down to small rounded grains. Their contours are subangular, but their angles are rounded. Their surface is not smooth and even, like that of pebbles subjected to continuous abrasion, but is marked by pits varying from a millimeter in depth to an occasional depth of four or five, and a width of six or seven millimeters. These pits were evidently formed by the corrosive action of the sea. In the presence of active currents abrasion is naturally in excess of corrosion, and pebbles formed under such conditions would not show the little pits here in question. The Belfast pebbles have evidently suffered, before being imbedded, from corrosive influences which were in excess of those of abrasion.

They resemble therefore the limestone pebbles of many less impetuous fresh water streams where abrasion plays a less important part, owing to the small velocity of the current. Such an origin cannot, however, be predicated of them. Their presence is certainly suggestive of shallow water condition over this part of the Cincinnati anticlinal region during the Clinton period.

Recent examination of Clinton oölitic iron ores has shown that in many places most of the so-called oölitic grains are the rounded fragments of small bryozoa, more or less replaced by iron ore. Sometimes the original bryozoan structure is not much altered and only the cell spaces are filled with iron ore, which also in this case probably represents original calcite material, that part which had penetrated into and filled the cells of the original bryozoan structures. Grains may be found where both the calcite of the bryozoan grains and their cell filling are unaltered; where the calcite of the bryozoa has been more or less replaced by iron ore, and is in marked contrast with the unaltered calcite cell-filling; where the calcite of the bryozoa is but little altered and that filling the cells is more or less replaced by iron ore; finally, where the calcite both of the bryozoa and that filling their cells are replaced by iron ore. In the last case the replacement may be so complete that the original bryozoan structure can no longer be detected. It will be remembered that in speaking of the Belfast conglomerate, pebbles were said to decrease in size until the smallest were only of the size of small grains. It is likely that some of these so-called oölitic grains, in which no structure can be detected, represent such fragments of older limestones, not of immediate organic nature, now replaced by iron. The general cement enclosing the grains is sometimes replaced by iron ore, while part of the included grains are still unaltered; reversed conditions are also frequent. These bryozoan remains were detected abundantly in the Clinton oölitic iron ores of the Alleghanies. They were examined only at one locality in the neighborhood of the Cincinnati anticlinal — the upper courses of the Clinton group along Todd's Fork, north of Wilmington, Ohio.

The presence of these small rounded bryozoan fragments is certainly indicative of the contemporaneous existence of currents. Such currents, however, might have been active in the deeper seas, and the existence of currents is therefore no indication of *shallow*

water conditions. In the present instance there is a probability that shallow water conditions *were* prevalent; the evidence for this, however, is not given by the bryozoan fragments, but by the *pebbles in the Belfast conglomerate*, only thirty-two miles southeast of the Todd Fork locality.

Do these facts prove the existence of the Cincinnati anticlinal in Clinton times? Certainly not; they merely suggest the existence of shallow water conditions over certain areas in Ohio, on the eastern side of the anticlinal crest. They do not exclude similar conditions over Clinton areas now low down on the flanks of the anticlinal. The probability is that shallow water conditions prevailed from Cincinnati group to Clinton times, in southwestern Ohio. To what extent these conditions were general in neighboring areas is not shown by the facts cited.

In the Niagara and Lower Helderberg groups succeeding the strata just discussed, the general supply of calcium carbonate decreases and that of magnesium carbonate increases. The result finds its expression in the few layers of true limestones, and in the general prevalence of dolomitic rocks. In the earlier strata of Devonian age the decrease of calcium carbonate becomes still more general, silica and clay ingredients appear abundantly and at less fitful intervals. The result is the continued appearance of dolomitic rocks, and the increase of shales as characteristic and important parts of the geologic series. In later Devonian strata the calcium carbonate plays an inconspicuous part; silica and clay ingredients form prominent constituents of the rocks. Even dolomitic rocks are scarce or altogether absent, and shales form the great mass of later Devonian strata. In Waverly strata east of the anticlinal, actual sandstones in which quartz is the prominent constituent begin to be prevalent, and in some parts of this formation the quartz grains are of sufficient size to be called pebbles. The quartz pebbles increase in size in later formations, and at the opening of the Carboniferous age, strata are found which fully merit the title—quartz conglomerates.

Now it is evident that the pebbles of these quartz conglomerates were not derived from the limestone areas of the Cincinnati anticlinal axis. Prof. Claypole has shown a general increase in the size of these quartz pebbles towards the east and has inferred a source from that direction. It is evident however that *none* of

the sandstones, whether containing quartz pebbles or only small quartz grains, could have been derived from Cincinnati anticlinal regions, since the *size* of the quartz fragments is simply a question as to the degree of comminution sustained. The earliest sandstones therefore, of Devonian age, are proof positive of a source of material different from the Cincinnati anticlinal area. Some of the Devonian shales, however, contain minute fragments of quartz grains readily visible in sections under the microscope. The larger of these also could not have come from the anticlinal. It is only a question therefore of numerous slides from various shales intervening between later Devonian and Clinton times to determine the earliest date at which the shales of Cincinnati group age *could no longer* have provided the materials for the shales of certain later strata. *Very* minute quartz grains *may* be present in Cincinnati group shales, and may have found their way into later formations.

When the rapid succession of shales and limestones in the Cincinnati group is considered it seems impossible that the great mass of Devonian shales could have derived the necessary materials for their formation from anticlinal regions without a much more pronounced intermingling of limestone elements from that source.

It is evident that an area which has become a seat of deposition ceases to be a source of supply to other formations. Thanks to natural gas excitement, and to Prof. Orton's skillful utilization of its results, we know that the anticlinal areas of Ohio now covered by strata of later than Clinton age show everywhere, at the proper horizons, characteristic Clinton strata. Connecting outliers of Clinton age in southwestern Ohio, with neighboring continuous sheets of that formation and with each other, the area of Cincinnati group rocks left exposed is considerably diminished. Imagining Clinton strata there where the thickness of the nearest still exposed Clinton areas, and their known rate of increase or decrease in thickness, would lead their former necessary existence to be inferred, the area of Cincinnati rocks still left exposed in Ohio, would be a comparatively small region in the vicinity of Cincinnati. Where a geologist might reasonably *infer* the previous existence of Clinton strata is likely to be determined largely by previous prejudices. There is no reason for denying their former existence, even over that area near Cincinnati, where their

existence is not *necessarily* inferred. In neighboring parts of Indiana, similar conditions prevailed in axial regions of the anticlinal.

The exposed portions of the Cincinnati group formations in Ohio during later than Clinton times being thus limited to that part of the anticlinal immediately adjoining the Ohio river, or even perhaps being confined to regions south of this limit, the area covered by the Clinton being still an area of deposition, how could the anticlinal area supply the immense mass of strata of later than Clinton age which cover and surround the anticlinal in Ohio. I doubt if mathematical calculations would not show that the erosion which has taken place over the entire area of Cincinnati rocks now exposed, would be insufficient to provide the materials for Upper Silurian, Devonian and Waverly formations in Ohio and Indiana alone, not considering the great mass of these formations in Kentucky and Tennessee. The continuous mantle of Clinton rocks in Ohio makes a source from more southern anticlinal exposures perfectly inadequate, while the different chemical constitution of succeeding formations makes their source from reerosion of Clinton strata also improbable—not considering for the present the improbability of much erosion in the Clinton before the deposition of the Niagara shales, which are found almost above every exposure of Clinton rocks in southern Ohio. These shales, however, already proclaim a widely different chemical constitution from that offered by Clinton rocks in these southern regions of Ohio.

If the anticlinal was in existence in Lower Silurian times, and provided the materials for later formations, the character of deposits on the eastern and on the western sides of this axis should not be essentially different, at least in the immediate vicinity of the anticlinal. What are the facts? Medina and Clinton formations in Tennessee are confined to the eastern side of the axis, and apparantly gradually become more attenuated in approaching the same, disappearing before reaching it. Niagara formations in this state, on the contrary, have a greater development west of the anticlinal, become attenuated eastward on approaching the crest of the anticlinal, beyond which they do not extend far, if at all. The Lower Helderberg occurs only west of the anticlinal, and also becomes attenuated eastward, disappearing long before

the axis of the anticlinal is reached. This separation of strata along the southern end of the Cincinnati anticlinal, certainly is as strong an argument against *this* portion of the anticlinal axis having been a source of supply of materials in the formation of the Upper Silurian strata of Tennessee, as were the facts above given against similar claims for the *northern* end of the same axis in Ohio. The Huron shales of Tennessee again cover the entire anticlinal, thus indicating that the peculiar conditions just noted in Upper Silurian times, had ceased. In Kentucky this separation of strata by the anticlinal region disappears on going northward. In Ohio it seems never to have obtained.

Although the Cincinnati anticlinal could not have provided the great mass of materials necessary for the formation of the surrounding Upper Silurian, Devonian and Carboniferous rocks, it is necessary to determine whether it might have formed a subaërial ridge, without providing any considerable share of these materials. Any land, for a greater or less time above the level of the sea, would at least be subjected to the effects of rain, and be more or less cut by the water channels, perhaps of a mild nature, along which the rain would find its way to the sea. The softer the materials forming the land surface, the more active would be the formation of such drainage channels. During submergence the lower courses of the channels would, for a time, be kept clear of sediments by the current still coming down along that part of the channel still above sea level. In the course of time sediments derived from the land, would cover these submerged channels; currents of the sea, even, might throw bars across them, or build flats or banks over them; but these subsequent deposits, would still, *in their structure*, give evidence of the uneven conditions they found when they began to cover up the old drainage channels. The presence of these, and similar positive evidences of the existence of land conditions over the whole range of the Cincinnati anticlinal axis, rather than the negative evidence derived from supposed or real absence of marine deposits during certain periods, over this area, are needed to determine this question. It has been shown above, that the Clinton conglomerate at Belfast, Ohio, can not be used as such a proof, and it is too limited in occurrence to serve as basis for any general conclusions.

It remains to consider the possibility of the Cincinnati anticlinal

not having been a subaërial ridge, and of its not having suffered erosion, but having, on the contrary, had its existence only as a submerged barrier obstructing the passage of sediment-transporting currents. The separation of strata of Upper Silurian age, as described from Tennessee, might be explained in this way: The facts from the northern end of the anticlinal are readily explained. Actual exposures of Medina are doubtfully identified at Wilmington, on the eastern side of the anticlinal, at Fair Haven, Ohio, on its crest, and at Hanover, Indiana, on its western side, the sandy strata so identified not appearing at the base of the Clinton *exposures* farther north in Ohio and the immediately adjacent parts of Indiana, at least. The Clinton crosses over from the eastern side of the anticlinal in northern Kentucky and Ohio, to the western side, and is identified with certainty at Hanover, Indiana, and the river counties of Kentucky, just south of Hanover. Clinton strata, however, with different lithological characteristics, are mentioned farther south in Kentucky on the western side of the anticlinal. The Niagara strata of western Tennessee are recognized again at Louisville, Kentucky, and with different lithological characteristics; also at Waldron, Indiana. In Ohio, on the other hand, the Dayton limestone alone could be mentioned in this connection, and it seems best to state that if the Waldron Niagara is represented in southwestern Ohio, it has unaltered lithological characteristics and definite correllation is no longer possible for the purposes here desired. The Guelph formations, a somewhat higher horizon, extend from Ohio across the Cincinnati anticlinal to central and northern Indiana. The Lower Helderberg strata also extend across the anticlinal in Ohio. Some of the outliers of later formations, still retained near the sources of the Scioto and Miami, near the middle of the Ohio portion of the anticlinal, rise to such a hight above the crest of that part of the anticlinal immediately adjacent, that there is no doubt but that the strata of which they are formed also once extended across the axis. These facts are not believed to be consistent with the existence of the Cincinnati anticlinal as an important barrier during paleozoic times.

The striking similarity of fossil forms in corresponding formations east and west of the anticlinal is also inconsistent with the existence of a significant barrier in those times. During the

Clinton period this similarity is very striking. It is observed in Guelph, Lower and Upper Helderberg periods. Even as late as Carboniferous times it would attract immediate attention if the anticlinal region be supposed to form a barrier. Thus the shales at the base of the Lower Coal Measures near Flint Ridge, at the eastern line of Licking county, Ohio, are full of marine fossils. The labors of Prof. C. L. Herrick have shown a striking identity between the mass of these fossils and those characteristic of the Coal Measures of Illinois, on the other side of the anticlinal. The bryozoa emphasize those observations, only one or two not being represented by forms in the Coal Measures of Illinois. Mr. E. O. Ulrich in a locality at the same horizon near Seville, Illinois, has discovered a fauna so closely related to the bryozoa of Flint Ridge that if he had chosen to publish his discoveries first, it would have been scarcely possible to give *good* specific distinctions for the Ohio forms. Considering the great variability usually shown by bryozoa, this decided similarity or identity must be considered striking, even if a barrier such as that which would be formed by the anticlinal axis, be not supposed to exist. This similarity, however, must appear almost incredible, with the anticlinal actually in existence.

The most valuable information in regard to the structure of the Cincinnati anticlinal is that accumulated by Prof. Edward Orton, and published by him in 1888 in volume VI of the Ohio Geological Survey.

By means of numerous records of wells bored during the late oil and gas excitement in Ohio, Prof. Orton was enabled to construct numerous sections of Ohio strata, with varying degrees of reliability, but all sufficiently accurate to add considerably to our knowledge of the geographical distribution of certain Paleozoic strata in the state. From these sections he constructed what might be called a contour map, with 250 feet intervals, of the Trenton as it would look at the present day if all superposed strata were removed. A glance at the geological map of Ohio, published by Prof. Newberry in 1879, would indicate an intimate correlation between the topography of this Trenton land and the present outcrops of Paleozoic strata in the state. An extension of this comparison to the immediately adjacent regions of Indiana

and Michigan would by no means diminish the importance of this correlation.

The dips and strikes of paleozoic strata in the northwestern corner of Ohio are so strongly conformable to the topography of the Trenton area in this region, and erosion has produced at the present day such a flattened topography, that projections of the outcrops of paleozoic strata are almost available for contour lines on the contour map of the Trenton strata as published by Prof. Orton. Thus the base of the Huron shale at its outcrops corresponds to the 1000-foot contour line on Prof. Orton's map. The base of the Corniferous limestone corresponds to the 750-foot contour. The base of the Waterlime agrees in a rough way with the 500-foot contour, finding its best expression along the axis of the Findlay fold, to be mentioned again later. The discrepancies are due chiefly to the more horizontal disposition of the strata along the flatter regions of the Cincinnati anticlinal, so that irregular erosion in these flat areas produces stronger impressions on the geologically colored map, than would be the case if the strata had been more inclined, as they are on the Findlay fold.

Outcrops of strata exposed between western lake Erie and the Ohio river along Adams county show similar correlations. Thus the base of the Waverly corresponds to the 1000-foot contour of Prof. Orton's map. The base of the Corniferous limestone, and where the Corniferous is absent, the base of the Huron shale, corresponds with the 750-foot contour. Again, the base of the Waterlime corresponds in a rough way to the 500-foot contour, this finding its best expression where nearest the Bucyrus fold, towards the Ohio river.

Where the base of the Waterlime outcrops follows a course more removed from the Findlay fold in the north, and from the Bucyrus fold on the south, it might be considered to correspond rather to the 250-foot contour. The base of the Upper Silurian exposures, however, corresponds quite closely with the zero or tide level contour on Prof. Orton's map. It must be remembered that this map gives the contours for the Trenton formations of Ohio, not of Cincinnati Group rocks, which of course show higher levels.

If these studies be continued it will also be found that palæozoic strata in western Ohio are more highly inclined and show narrower limits of outcrops there where also the Trenton topogra-

phy indicates more inclined strata. The maintenance of Waterlime strata in southern Hardin county in spite of the erosion along the headwaters of the Scioto is perhaps in correlation with the topographical depression of the Trenton on Prof. Orton's map. In a similar way, the extension of the Waterlime outcrops westward to the western limit of Champaign county may be connected with the depressions on the corresponding part of Prof. Orton's map. These later conclusions are perhaps rather forced.

If now these investigations be extended so as to include the reconstructed sections of the rocks overlying the Trenton in different parts of western Ohio, this correlation is still further exemplified. Thus it has been possible to trace out a fold whose axis extends through Bowling Green, North Baltimore and Findlay, and which involves all strata from the Trenton to the Huron shale. But it is this Findlay fold which gives such great relief to the Cincinnati anticlinal in northwestern Ohio.

Other sections between western lake Erie and the Ohio river, along Adams county, show another pretty strong fold, whose axis lies somewhat west of a line passing through Sandusky, Bucyrus and Delaware, and thence southward. This fold likewise involves all the strata from the Trenton to the Huron shale, possibly also the Waverly. This Bucyrus fold is in *its* place the chief factor giving relief to the Cincinnati anticlinal, defining its *eastern* boundary in Ohio. Both the Findlay fold and the Bucyrus fold involve formations as high as the Huron shale. What is there to prove that these folds are not, therefore, of later age than at least the Huron shale? It seems even possible that they may be later than the Waverly.

Fremont and Sandusky are 21 miles apart; the Trenton at these two cities differs 927 feet in altitude. Carey and Bucyrus are 23 miles apart. The Trenton here differs 722 feet in altitude. In both cases the difference in altitude would be magnified somewhat if the sections had been made directly across the strike of the formations involved. Now, what is the increase in the thickness of the sediments seaward, in this case eastward, corresponding with this slope of one foot descent in every 120 to 170 feet down the side of the anticlinal? Practically nothing. In other words, the folds which now form the chief features of the Cincinnati anticlinal cannot be supposed to have existed in Trenton times.

To state that the Cincinnati anticlinal may have existed at the close of the Trenton period without the assistance of the Findlay and Bucyrus folds, but in a less marked degree, seems like begging the question, since these folds practically constitute the Cincinnati anticlinal. Since these folds are of later age than the Huron shales, and even perhaps were formed in later than Waverly times, what reason is there to suppose that the small amount of folding displayed in its Cincinnati anticlinal, which remains when the Findlay and Bucyrus folds are not considered, took place in times soon after the Trenton period; that is, in times later than the age of Cincinnati group rocks, rather than in times later than the Huron shale or even later than the Waverly period?

As a result of the considerations here presented, the conclusion has been reached that the structure known as the Cincinnati anticlinal is a fold of considerable length, formed in later than Huron shale, and probably later than Waverly times; and, that for this reason, all formations from the Trenton to the Huron shale, are found to be involved in this fold. This conclusion is chiefly valid for Ohio, since almost all arguments are drawn from observations made in that state. The correlation of this anticlinal with the post-Carboniferous folds of Pennsylvania seems natural, and is suggested by the facts cited in regard to the Flint Ridge fossils above.

The thickening of strata, going eastward from the anticlinal, has among other things suggested the origin of these strata from the Cincinnati anticlinal. Taken in connection with wider observations they prove the contrary. As a general rule all palæozoic formations decrease in thickness in going from the Alleghany mountains westward to the Cincinnati anticlinal. The coarser strata, as a rule, also are found in the Alleghany belt, and are represented by finer sediments westward. This indicates a great region east of the Alleghanies, as the source for the sediments which diminish in thickness westward towards the Cincinnati anticlinal.

In the same way, a thickening of formations takes place in certain horizons in going northward from Cincinnati to the northern part of Ohio. I will refer here only to the presence of the Medina there, and the increased thickness of the Clinton, as shown by well-borings in the northern part of the state; also, to the

correlation of this increased thickness with the change from an almost pure limestone to a sandy rock northwards. This points to a second source of material for certain of the formations involved in the anticlinal, from a region north of the Great Lakes. Again, the increase of the true Niagara limestones, and later, of the Helderberg rocks in going westward from the anticlinal through Indiana and adjacent Kentucky, taken in connection with similar phenomena along similar horizons in Tennessee, suggests that in portions of the palæozoic series, an origin for sediments must also be sought in regions west of the anticlinal.

The anticlinal, therefore, instead of being itself a source of sediment for succeeding formations, seems to have been near the least sediment-favored median line of a great sea, into which vast amounts of sediments were deposited. Most of these sediments were derived from a continent east of the Alleghanies. A large share also was probably derived from Canadian areas, then above water. During the Upper Silurian and, perhaps, also a part of the Devonian, a region west of the Mississippi may have been a source for sediment. The coarser sediments were deposited nearer the source in each case; the finer was deposited in regions more distant. The Cincinnati anticlinal, taken as a whole, is a region where the least sediments were deposits, since it was most remote from these sources. It seems to have formed a line of weakness, and hence it was natural that the strong folding caused in the Alleghanies by a pressure from the east, almost disappearing entirely before reaching Ohio, central Kentucky and Tennessee, should find a last expression in the Cincinnati anticlinal.

The purpose of this paper was to discuss the age of the Cincinnati anticlinal. A fuller examination into the various statements following this discussion, must be reserved for another time.

THE "HERCYN-FRAGE" AND THE HELDERBERG LIMESTONES IN NORTH AMERICA.

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Dr. Novák has been the strongest supporter among the Bohemian geologists of the propositions involved in the "Hercyn-Frage," as suggested by Beyrich and more fully elaborated by Kayser, and he is the first to undertake a comparative study of

any single faunal element in the various developments of the Hercynian. This Hercynian discussion involves primarily the transference of a certain fauna in the northwest Hartz, considered by A. Rœmer as upper Silurian, to the Devonian and as one of its consequences, the subdivision of M. Barrande's "Silurian Basin" in Bohemia, leaving the Silurian to terminate with his étage e_2 or with f_1 and referring f_2, $g_1 + _2$ and perhaps also H to the lowest Devonian. The controversy over these and other issues of the question has been prolific in literature for ten years past* and has an important bearing upon the Lower Helderberg fauna of North America and its relations to the normal Silurian (Niagara) and to the Devonian. Dr. Novák's* work does not, unfortunately, aim at completeness. He has brought together certain trilobites occurring in the Rhenish and Westphalian Hercynian and with them compared similar or identical forms in the Bohemian. Not all the species or genera known from the German localities are introduced nor are some important Hercynian genera brought into consideration at all (notably *Dalmanites*). The following genera are discussed: *Proëtus*, *Arethusina*, *Tropidocoryphe* (new), *Phætonellus* (new), *Cyphaspio*, *Cyphaspides* (new), *Phacops*, *Harpes*, *Lichas*, *Acidaspis*, *Cheirurus* and *Bronteus*, and remarkably high percentages of the forty-one species and varieties described are found common to the German and Bohemian localities. Without entering into the special bearings of these discussions there are some facts elicited which have an interesting relation to the trilobite element in American faunas of equivalent value. The great development of the *Proëti* (nine species and one variety) is in sharp contrast to their meager representation in American faunas prior to those of the Upper Helderberg, and in consonance with their remarkable abundance and variety in these latter faunas. Of these proëtids certain characteristic types are present both there and here. The most prolific there being species of the typical group, i. e., conforming with the structure of *P. cuvieri* in having a regularly convex truncate-ovate glabella extending from

*The writer has given a resumé of the more important phases of this discussion in the Report of the State Geologist of New York for 1888.

*NOVAK. Vergleichende Studien an einigen Trilobiten aus dem Hercyn von Bicken, Wildungen, Greifenstein und Böhmen. Dames and Kayser's Paläontologische Abhandlungen. Neue Folge. Bnd 1. Heft 3. 46 pp., 5 plates. 1890.

occipital ring to anterior border, with furrows and lobes faint or obsolete, rounded genal angles and relatively broad rhachis on the pygidium; a type not common in America, but represented in the Lower Helderberg by its only species, *P. protuberans* Hall and in the Corniferous limestone by *P. folliceps* Hall. A second, less abundant type is that of *P. eremita* Barrande (étage f_2), characterized by the shorter, more subquadrate, depressed and furrowed glabella, and especially by the short pygidium with narrow, acute rhachis and obscure pleural annulations; with this may be compared the *P. corycœus* Conrad, of the Niagara group, probaby the only representative of this phase of structure known in our faunas. A third is that of *P. holzapfeli* Novák, (*Æonia* Burmeister) with violin-shaped glabella and spinous genal angles, as in *P. canaliculatus* Hall of the Corniferous limestone; a fourth, *P. waldschmidti* Novák, which seems in most respects to exemplify the type of structure represented most abundantly in our Palæozoic faunas, as shown in *P. augustifrons* Hall of the Schoharie grit, *P. clarus* Hall, of the Corniferous, *P. rowi* Green, *P. prouti* Shumad, *P. phocion* Billings, *P. nevadæ* Hall, of the later Devonian. A fifth type of structure is *P. filicostatus* Novák, which is remarkable for its broad, flabellate pygidium and rapidly tapering glabella, characters which the author has considered of such distinctive importance that he has proposed to designate the group which it represents by the new term *Tropidocoryphe-Prionopeltis* Corda, in part. With these forms may be compared the *P. planimarginatus* Meek, of the Corniferous limestone. Another and sixth type of proëtid structure is represented by *P. planicauda* Barrande, a form with fimbriated pygidium, but differing from *P. archiaci* Barrande, and other species belonging to the subgenus *Phætonides* Barrande, in the shorter rhachis and fewer annulations of the pygidium. For this group, represented by the form mentioned and *P. dentatulus* Novák, the subgeneric term *Phætonellus* is proposed. It is probable that the *Phæton denticulatus* Meek, from the Devonian of Nevada, is a member of the same group, while it is a matter of doubt whether typical forms of Barrande's *Phæton-Phætonides* (not *Phætonides* Angelin) have been found in our palæozoic faunas. The author establishes another new generic group, *Cyphaspides*, which is based upon a peculiarly subquadrate pygidium having in general the structure of

that in *Proëtus*, but with the extremities of the abruptly reflected annulations produced into short spines. In this genus, of which much is to be learned, are included five species from Bohemia, the Rhine and the Hartz.

Cyphaspis appears in one species (*C. hydrocephala* Rœmer), a near ally of *C. minuscula* Hall, of the Corniferous limestone.

The reappearance of the genus *Arethusina* from the middle Silurian is a feature of interest.

The species of *Phacops* all have the peculiarities of the early representatives of the genus, well defined, linear glabellar furrows, and grooved pygidial pleuræ, being in contrast to the later representatives in which both characters are obsolescent. The species of the Lower Helderberg, Oriskany, Schoharie grit and Corniferous limestone are all provided with these features, while *P. logani* the abundant species of the Lower Helderberg, alone has the lobation of the lateral margins of the axis which characterizes *P. breviceps* of étage f_2. The form described as *Phacops* cf. *Zorgensio* Kayser has the subpentagonal glabella characterizing an undescribed species in the Oriskany of New York.

Lichas haueri is closely allied to *L. ptyonurus* Hall from the Coralline limestone (Niagara) of Schoharie, N. Y., and *L.* (*Arges*) *maureri* is represented in the Corniferous by *Arges contusus* Hall. In *Acidaspis vesiculosa* Beyrich we have a type of structure which was designated by Corda, as *Trapelocera* and by Warder as *Ceratocephala*. The group has but a single known representative in American faunas, *A. danai* Hall, of the Niagara group, a synonym of *Ceratocephala goniata*. Warder. *Acidaspis pigra* Barrande, differs from *A. callicera* Hall of the Upper Helderberg in minor respects only.

Crotalocephalus (*cordai*) is represented in the Niagara fauna by *C. niagarensis* Hall, but with this species the existence of the *Cheirurus*-type ended, as far as known, in our Palæozoic. The abundance of *Bronteus* with spinous pygidial margins, is a feature emphasizing the Devonian value of the faunas. This type of structure (*Thysanopeltis* Corda) attains a maximum development in the later Devonian, and with us, is represented in the *B. tullius* Hall, of the Tully limestone, while it does not appear in any of the earlier faunas. The Niagara species and the Lower Helderberg, *B. barrandii* Hall, have smooth-margined pygidia and of

these forms we find a representative in these Hercynian species in the *B. dormitzeri* var. *applanatus* Novák. On the whole the comparison of the Hercynian trilobites discusssd by Dr. Novák with their American equivalents brings out several important points of correlation with our typical Silurian (Niagara), some with the Lower Helderberg, but most emphatically with the limestone faunas of the Upper Helderberg.

NATURAL AND ARTIFICIAL TERRACES.

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The subject introduced by the title given above has been discussed in the pages of the American Antiquarian until the danger of dogmatism on both sides suspended it, and the advice was given, let us seek for more facts. It may seem a puerile enquiry but the writer presumes upon the candor and charity of the geologists to put the case briefly before them for further examination.

It might here be stated that Ohio is the state in which archæologists have claimed that they have discovered artificial terraces, but it is also the state in which natural terraces are very numerous, some of which are quite likely to be mistaken by unskilled observers for artificial works. The first case of this kind which has gone into any record was that which has now become very familiar, namely the well known terraces at the southwest corner of the enclosure at Ft. Ancient. The authors of that extremely valuable book, "Ancient Monuments," Messrs. Squier and Davis, maintained that this terrace was a platform placed on the escarpment for the sake of defending the fort from attack and for the sake of keeping a watch of the river bank which is still so plainly visible from the spot. These artificial terraces are laid down on all the maps and diagrams of the fort and very few have undertaken to correct the error for the very reason that it is still uncertain whether it is an error or a correct observation. Still in reference to these platforms we may say that every attempt to prove them artificial has, to our mind, brought out more clearly the proofs that they were natural. To illustrate—Mr. Warren K. Moorhead in his recent book on Fort Ancient mentions the terraces and then goes on to say that terraces similar to these are

found at several places in immediate vicinity as follows; on the bank of the river opposite, on Mr. Ridge's farm, and on Mr. Cowden's place, but he states that the hight of each terrace is about the same, varying from 135 ft. to 137 ft. above high water. Mr. Brown, the editor of the Waynesville Gazette, once took the writer around among these terraces and from these to others ten miles away on Cæsar's creek, and near Waynesville. The result was that each terrace was shown to have about the same general level, and to the writer were plainly natural.

There are, however, those who still insist that pottery and arrow heads and the remains of encampments are so common on these terraces that they must be artificial. It is also maintained that the Indians knew about these terraces, and that in marching against a tribe they would traverse a terrace as far as it extended. All that we have to say about this is that Indians did not throw up highways along the sides of bluffs to march on, and it would be about as reasonable to say that Indians built railroads, as to maintain that they built these terraces as roadways for themselves. The fort near which these terraces are seen is, to be sure, the oldest of the two forts, and was, as Mr. Moorhead states, for a long time the site of an ancient village. It is the opinion of the writer that the people who built this "old fort" were the very people who built the great Serpent Mound and that they were a very wild race, in fact were serpent-worshipers, but the people who built the new fort were a much more cultivated people, agriculturists and sun-worshipers, yet neither of them were advanced enough to erect artificial terraces like these. The geologist will be able to tell us something about the causes which were at work when these upper terraces were formed, and they may possibly help us to solve the problem as to the time when the first races of Mound Builders were likely to have come on the stage of action. The terminal moraine we understand extends down into this region on the Ohio, and the paleolithic people, so called, are supposed to have followed up the ice sheet and to have dropped their rude weapons into the water or upon the ice, the gravel proving to be the safe depository for them until the days of railroads and modern modifications of the earth's surface. The "disturbed" gravel reveals the early advent of man, though whether he was the ancestor of the Eskimo or not is now unknown.

There is, according to archæology, a wide gap between these Eskimo paleolithic fishermen or "Littoral" people and the wild hunters of the forest who first erected their mounds above the terraces; and this gap we are now anxious to fill up. In Europe the Reindeer period comes in between the gravels and the mounds and the episodes are found in the various caves and their contents. In this country we seem to have a Mammoth or Mastodon period overlapping the gravel beds and coming down very near to the time of the Mound Builders, but the reindeer seems to be absent. We have in addition the caves which have recently been discovered in Kentucky near the Mammoth cave with its 2000 reputed skeletons to examine. We have also the peat swamps of Michigan and of northern Ohio with their various deposits of mastodon bones closely associated with arrowheads and traces of fire. We have the various thick-skulled and strange-looking waifs which turn up occasionally among the mounds to show that there was a race which intervened between the so-called Eskimo fisherman of the Glacial period and the early hunter of the Mound Building period. It may be that during the Pleistocene age these natural terraces were occupied and that some relics may yet be found on them which will prove to be those of the very early race which intervened between the gravel beds and the mound period.

In reference to the survival of the mammoth or mastodon to the time of the Mound-builders, perhaps a word or two may be proper. Here the subject of terraces helps us but little, and yet there is a hint from them. The celebrated Elephant mound, which is now destroyed, was not on any terrace; but was in a swale, and so low down in the swale, that the high water frequently overflowed the surrounding land. The writer has visited this spot several times. The last time he had the opportunity of seeing the effigy brought out in relief by the crop of clover which was growing on the "elephant," but which had been killed out by the high water on all the land adjoining.

The elephant must have been exceedingly modern, about as modern as the buffalo, if this effigy was a genuine imitation; but the writer believes that the bear or buffalo was the tribal totem of this region, and that no mastodon was known to the tribe who left the effigies on the soil. Every "elephant" has been exploded, and even elephant pipes are exceedingly doubtful specimens. Still,

the elephant or mastodon may be found along with the remains of man before the Mound-builders, and some of the terraces may yet reveal the two together.

It should be stated that the river-terraces which stretch down from the second glacial moraines toward the track of the first glacial bed, are all covered with traces of both mound-builders and Indians; and, superficially considered, they furnish no evidence of the intermediate race.

There are, however, some interesting facts about the terraces as modified by human action. The writer once visited a spot on the Cuyahoga river in which the beautiful scallop work was traced from hill to hill, each scallop being the fragment of a terrace. Standing there in company with several archæologists, who had been preparing for the great Centennial Exposition, in which Ohio prehistoric relics figured so conspicuously, the little company looked at the ground on which they stood, and found that it was actually a truncated pyramid which had been artificially wrought out of an outlying fragment of one of the terraces, and was a most beautiful piece of artificial earth carving on a large scale. The summit was level and the sides presented a smooth and even slope with angles accurate, and the whole remarkably symmetrical. At the time referred to, the company seemed to be sceptical about the artificial character of this work, though the moulding of natural terraces or fragments of terraces is not uncommon. The writer has since then seen so many evidences of artificial handiwork in connection with natural eminences and ridges, that he has ceased to be surprised. Ridges of sand will sometimes be modified so as to resemble animals. River banks will be noticed with rows of mounds or effigies parallel to them. Bluffs will have semblances to birds, serpents and other animals, and the artificial work on the summit will make the semblance all the more striking. It is a fancy with the writer that the sides of certain hills have been modified to bring out the "Phallic Symbol" and that a rude moulding of the terraces and escarpments was sometimes practiced to show more fully the animistic conception which made the bluff or cliff or drummel or even terrace the abode of the great spirit of all the animals, the totem of the people who inhabited the region.

We have followed the terrace up from the paleolithic gravel to

the intermediate cave period and from that to the mound period, and have found each age full of problems. The swamps and swales and low lands were frequented by Indians. The sand ridges, the "cypress swamps," the first, second and third terraces along the river valleys were occupied by Mound Builders with their villages on the rich plains, their forts on the high bluffs, their pyramids rising out of the flood plains, but there is nothing to distinguish the age of any of them except the faint traces of a differentiation in their art and architecture. Possibly the geologist may discover in the cuts and erosions, and beneath the loam, in the peat beds, among the shelter caves, in the grottoes or beneath the gravels that part of the record which has so far baffled us, and will help the archæologists solve the problem of man's existence on this continent.

We do not claim the terraces to have been artificial, we are not sure that many of them have even been moulded, but the remains and the tokens of man are upon them and beneath them, and both the geologist and the archæologist may study them.

ON A JOINTED EARTH-AUGER FOR GEOLOGICAL EXPLORATIONS IN SOFT DEPOSITS*.

By N. H. Darton, U. S. Geological Survey.

In the ninth report of the director of the U. S. Geol. Survey for 1887-8, Mr. W. J. McGee briefly described a jointed earth-auger which he employed successfully in exploring the superficial deposits about Iowa City. In my investigations in Atlantic coastal plain geology, I have used the instrument with great satisfaction in boring to depths from five to forty feet, and I now wish to describe the details of its construction and use together with some modifications which have greatly increased its efficiency.

The improved form of instrument consists of an auger bit; a number of three-foot lengths of one-fourth-inch iron pipe; a cross-bar handle, all with threads and couplings for connection to any length required, a pair of pipe tongs and a receptacle of some kind.

The bit should consist of an ordinary one-and-a-half inch carpenter's auger with two or three whorls of double spirals, welded to a one-half-inch iron bar to extend its length to three feet.

*Read to the Geological Society of America, Dec. 30, 1890.

Short plugs of one-fourth-inch iron bar forged into the ends of the pipes before they are threaded, greatly increase the strength of the instrument, for the greatest tranverse strain is at the couplings. Solid bar may be used for the lengths but the strength of the piping with plugs is practically as great and the weight is much less. The coupling on an end of each length should be screwed on very tightly and galvanized couplings are preferable on account of their greater strength. The cross-bar should be forged from one-half inch iron bar with handles about a foot long on each side and the vertical stem about an inch long with a coupling screwed on very tightly. The adjustable gas *tongs* No. 1, are better than any form of pipe *wrenches* so far as my experience goes for they are highly effective and not liable to get out of order. A base-ball-bat bag is a satisfactory receptacle for the entire outfit for it will hold from twelve to fourteen lengths without difficulty and is convenient to handle.

In use the bit is extended by screwing on length after length until the desired depth is bored. Care must be taken to make the joints as tight as possible for it is frequently necessary to unscrew the bit from the material in which it is being bored and sometimes it becomes quite tightly wedged. Usually the instrument must be withdrawn from the hole at about each six inches and the borings removed. In very compact materials less, and in loose soft sands more, can be brought up each time. Below a depth of twenty-one feet the rod should be disconnected into two sections each time it is raised unless there are some convenient branches or projections overhead against which its upper part may lean.

In pebbly materials progress is very unsatisfactory or impossible unless the pebbles are very small. Quicksand is another adverse condition, and of course no progress could be made in lithified materials of any appreciable degree of hardness.

I have made borings down to a depth of forty feet but if the texture of the materials is favorable and the rod is disconnected into three sections each time it is brought up, (every three to eight inches) a much greater depth could probably be attained. The labor of working the instrument is not great if care be exercised not to bore too deeply at a time and although one man can make good progress in soft materials it is economical to have assistance.

The degree to which a vacuum is formed below the auger when it it is being raised depends of course on the nature of the walls of the boring and the material on the auger, but in depths to forty feet I have seldom found the air pressure very great and never an insuperable obstacle.

The instrument is simple and inexpensive and will prove a useful means for obtaining data in regard to soft deposits at moderate depths.

CONTRIBUTIONS TO THE GEOLOGY OF THE SOUTHWEST.

By Robt. T. Hill, Austin.

[Note.—These papers will contain brief announcements of the results of scientific exploration in the Texas Region of the United States, to-wit: southern Indian Territory, southwest Arkansas, Texas, eastern New Mexico and northern Mexico.]

The altitude of Mount Scott.—Mount Scott is one of the highest peaks of the Wichita mountains. It is situated about 12 miles west of Fort Sill, on the Comanche reservation in Indian territory, and consists entirely of massive granite, mostly composed of red feldspar. I recently measured this mountain with the assistance of the U. S. signal officer at Fort Sill, who made mercurial readings while I climbed the mountain with my aneroid. Altitude of summit 2305 feet; altitude of plain at base of mountain, Fort Sill signal station, 1,200; altitude of Red river, sixty miles south, 750.

A new Silurian area of the United States. In the central portion of the Chickasaw nation extending from Wahpemick Academy to Duncan, including the Arbuckle mountains, there is a grand development of Silurian limestone and shales, of various ages from Trenton to Helderburg, as determined by Prof. H. S. Williams, from fossils sent to him, and perhaps later or Devonian. These will be described by the writer in the next issue of the Geologist.

The age of the Comanche Series. The Ninth Annual Report of the U. S. Geological Survey announces that Dr. C. A. White has been continuing his investigations into the Comanche series, "the age of which he determined last year." To one like the writer who has been studying these rocks for many years for the purpose of ascertaining their age, the announcement of Dr. White's deter-

mination will be interesting, especially since he no longer considers this great series a southern deeper continuation of the Meek & Hayden Series, as was his published opinion when the writer first had the pleasure of pointing out these rocks to him in 1886. Prof. F. W. Cragin, who has been studying these rocks in southwest Kansas, where they occur in very different conditions from Texas, in the last issue of this magazine, p. 23, has decided to drop the name Comanche series, and call them Neocomian, after Marcou; so far have his studies progressed. The writer must confess that, from his own continuous studies of this great series he still feels undecided as to their actual synchronism, and considers the term, Comanche series, first proposed by him, still the most appropriate until more complete investigations are made.

Cretaceous Inliers. The great erosion to which the surface of the southwest has been subjected reveals a number of inliers of upper Cretaceous beds in the Eocene area of Arkansas and Texas. All of the Cretaceous outcrops of Arkansas are of this nature, being seen only where the post-Cretaceous beds of the Marine Eocene and Plateau Gravel (Quaternary) epochs have been cut through by the drainage. Many of these inliers occur in the Eocene area of Texas, notably at the Friese place, in Bowie county, near Palestine in Anderson county, and at other places as have been described by Lawrence C. Johnson in his report on the Tertiary Iron ores of east Texas. It is an interesting fact that all of these inliers are in the direct strike of the beds of the Glauconitic division of the Upper Cretaceous, only the base of which, as at Corsicana and Webberville, are exposed in the eastern edge of the main Cretaceous area, thus showing that the great beds of that division, which is the equivalent of the Ripley—rotten limestone—Tombigbee division in Alabama, are still mostly buried beneath the Eocene overlap in Texas.

A New Source of Artesian water in Texas. In the American Journal of Science for April, 1887, the writer published the preliminary announcement of the Fort Worth-Waco artesian area, which is now known to extend from Denton to Del Rio, a distance of 500 miles, and to be one of the most prolific artesian areas in the world, several hundred wells and numerous rivers which have their origin in fault-springs like those at Del Rio and San Antonio.

showing no appreciable diminution of the supply which has its source in the Trinity sands at the base of the Comanche series. During the past two months from the wells at Pottsboro and Dallas, I have discovered that the Dakota sands are also the source of anothei valuable artesian area, which although not so extensive as the Forth Worth–Waco area will prove of great economic value to Texas.

"Llano Estacado" or "Staked Plains." An interesting question of nomenclature is whether or not the name Staked Plains should not be dropped from geographic nomenclature as the descriptive name for the great mesa to which it is applied. One popular apology for the use of this term is that early travelers set up stakes to mark their roads over these—then considered—waterless wastes. Another is that the term alludes to the staff-like stems of the Yucca plant which resemble stakes projecting above the ground. Neither of these hypotheses, however, will stand the test of application, for the traveler could not possibly have secured on the absolutely treeless plains timber wherewith to make his stakes, and the Yucca does not grow upon them. Upon the other hand, a glance at the Spanish dictionary will show that it will be impossible to translate the word "estacado" to mean a stake, but upon the contrary it means exactly the opposite—a palisade or wall, which is a most apprópriate descriptive term for the Llano Estacado, inasmuch as it alludes to the sharp declivity or face of the escarpment which in many places marks the edge of these plains. In view of these facts is it not as erroneous to use the term Staked Plains for the Llano Estacado as to write the name L'Eau Frais, "Low Freight," as is done upon Colton's maps of Arkansas? It may interest some to know that instead of being waterless, these great plains are now known to be one of the greatest water-bearing formations in America, over 1,000 wells already having been bored, furnishing an abundance of water to the rapidly increasing population.

The Dakota Sandstone in Arkansas. I have connected the Arkansas area of the Cretaceous with Texas in the past season's field labor, and in the course of these investigations mapped out the extent of every terrane in southern Indian Territory and north Texas, besides visiting all the historic Cretaceous localities, such as the Plains of the Kiamechia, from which the original type speci-

mens of Gryphæa pitcheri Morton were collected and sent to Dr. Morton, and old Fort Washita, in Indian Territory, where Mr. Jules Marcou made his observations, and all the localities mentioned by Drs. G. G. and Benj. F. Shumard. An interesting result of these labors was a complete study of the stratigraphy of the Dakota sandstones which were first recognized by Dr. B. F. Shumard in 1860, from fossil leaves at Denison, Texas.* These beds, I found, have a grand development from a few miles east of Gainesville nearly 200 miles east into Arkansas, where they outcrop in a single locality in the bed of Little river, as described but not identified on p. 182 of my report on the Neozoic geology of southwest Arkansas. Red river flows in the strike of these beds all the way from seven miles east of Denison, Texas, to the old Paris Fort, Towin Ferry, grand exposures being seen beneath the river alluvium and Quaternary beds in all the bluffs. At Arthur's ferry, where the St. Louis and San Francisco road crosses Red river are magnificent plant beds abounding in innumerable individuals of all the typical Dakota dicotyledonous leaves. In addition to this flora, there are interesting occurrences of molluscs (which are rare in the northeastern United States), which will give great light on the paleontology of the Dakota sandstone. The relation of these beds to the shallow and somewhat similar lithologic beds of the uppermost Lower Cretaceous is clearly unconformable, although casual observation would no doubt lead to their confusion. This tongue-like extension of the Dakota, eastward, clearly is all south of the Wachita mountains, and gives new light on our Cretaceous history.

MEGALONYX IN HOLMES COUNTY, OHIO, 1890.

By E. W. Claypole, Akron, O.

I.

About the end of December, 1890, there appeared in a local paper, the "Millersburg Farmer," a notice of the discovery of some large fossil bones in a swamp near that town. Supposing that they belonged to the Mastodon whose skeleton is frequently found in an imperfect condition in the swamps of the state, I

*Trans. Acad. Sci., St. Louis, Vol. II, p. 152, 1861.

traced the communication, and secured through the courtesy of its editor, Mr. G. F. Newton, a copy of the paper in which mention was made of large claws and the belief expressed that the bones were those of Megalonyx and not of Mastodon. Further correspondence elicited a letter from Mr. W. S. Hanna, prosecuting attorney of Holmes county, by whom the identification had been made and fully confirmed the belief above expressed. I then visited Millersburg and on Jan. 10th, in company with Mr. Hanna, went out to the place where the bones had been found. The swamp in question lies about seven miles to the northeast of Millersburg on the farm of Mr. Drushell, and it was in the course of digging a ditch for the drainage of the same that the bones were discovered. Great care and intelligence had been displayed in extricating them by all the parties concerned. The bones were in excellent condition, and had been thoroughly washed with hot glue by Mrs. Drushell to preserve them. They showed no tendency to crumble and were nearly as heavy as if recent and dry. The first glance left no doubt regarding their nature. They were really, as asserted, the bones of Megalonyx. The owner gave me full permission to make all the notes and drawings desired, and from what I saw and heard the following account is drawn up.

I. *The bones found.*

The following contains the anatomical details of the find:

Femur,	two; about twenty in. long by 8 in, wide.
Tibia.	one.
Radius,	one; 20 inches.
Fibula,	two.
Clavicle,	one.
Patella,	two.
Vertebræ, lumbar,	three.
caudal,	one.
cervical?	one; broken.
Calcaneum,	two.
Hyoid,	one.
Phalanges,	nine, excluding claws.
Metacarpals and Metatarsals,	five.
Carpals and Tarsals,	twenty-two.
Ribs, whole,	three.
broken,	five?
Claws,	eleven.
Teeth,	three.

Altogether about 80 bones have been recovered from the swamp, of which nearly all are in excellent condition. The skeleton is

therefore still very far from complete. The total number of bones must have been nearly 250. About two-thirds are consequently still missing.

It will be noticed that the list shows only five out of probably 50 vertebræ, and no part of either skull or pelvis except the three teeth. The second tibia is missing, also one radius and both ulnas, besides many of the smaller bones and fifteen out of the eighteen teeth. There can be little doubt that some if not most of these will be found when the weather permits further search. At present the work is suspended, but it will be resumed later.

The animal's hind legs lay close to the north side of the ditch, and would have been missed had it been dug a little farther to the south. But on striking the first bone the interest excited led to extensive digging, and one after another was brought to light.

II. *The ground.*

The ditch is dug through peat to the depth of six feet where a layer of shell-marl occurs, and on this or slightly embedded in it lay the skeleton. The plan pursued was to scarp the peat on the north side of the ditch down to the marl, and then to probe with a rod into the soft upright wall till a bone was struck, when the peat was carefully removed or undermined by two of the workmen, two others examining with their hands every shovelful that was thrown out so that even the smallest bone could scarcely escape notice. In this way a hole 20 feet by 15 had been excavated down to the surface of the marl. It was found necessary to dig down for a short distance into this in order to extricate one or two of the bones that seemed to have been pressed into it by their weight or by that of the overlying peat. But none of them were really buried in it, so that the death of the animal had apparently taken place since its formation and near the beginning of the accumulation of the peat. To the depth and the nature of the material the bones seem to owe their preservation. It is observable that one or two of them, a claw for example, that occurred at a rather higher level were considerably decayed.

III. *Affinities of Megalonyx.*

Megalonyx is one of the less known members of the order of Edentates, the best known of which are the sloths. This order comprises the lowest portion of the Eutherian subtribe of the

mammals. The living members are well differentiated from each other, but a slight acquaintance with its palæontology suffices to show that this sharp definition is due to the disappearance of many intervening links that have dropped out of existence. The extinct members of this family far outnumber and outweigh their survivors. Its glory has departed and it is now represented on earth by small and degenerate descendants of huge and powerful ancestors, albeit we must doubtless grant that the former are better fitted to the environment of the day than would be the latter.

South America is now, and so far as we know always has been, the metropolis of slothdom. More of the Edentate order now live on that continent than in any other part of the world, and it has yielded to our museums the greatest abundance of the gigantic fossil forms. Both the living and the extinct are alike distinguished by certain features that mark them off from all other Mammalia. There is no enamel on the teeth, and no incisor or canine teeth are found (with a few exceptions) in any of the Edentates recent or extinct. The teeth are all of the same pattern, are not shed, and grow during the whole life of the animal. Some of the family are also remarkable for being the only mammals that develop a hard external skeleton, the Armadillos and Glyptodons, for example.

Not a single Edentate has been found on the continent of Europe, nor, so far as is known, has any one ever lived there. Northern Asia and Australia have also yielded no traces of the order. But from South America its members ranged into the southern part of North America, and by means of land communication that has since been destroyed, into Africa and southern Asia. The hairy ant-bears of Ethiopia, the scaly pangolins of India and Africa, and the Armadillos, ant-eaters and sloths of South America are all the species of the order that now survive. Of these the last only exceed a fox in size, while few of the rest are larger than a rabbit.

The following are the families into which the order is divided:

1. The Orycteropodidæ or Ant-bears.
2. The Manidæ or Pangolins.
3. The Dasypodidæ or Armadillos.
4. The Myrmecophagidæ or Ant-eaters.
5. The Glyptodontidæ or Glyptodonts (extinct).

6. The Bradypodidæ or Sloths.

7. The Megatheriidæ or Megatherians (extinct).

The first five of these require no further notice here, not being sufficiently cognate with the subject. There remain only, therefore, for consideration one living and one extinct family.

The tree-sloths, to which of all existing species Megalonyx is most closely allied, are among the most singular of living mammals. They have been pitied by naturalists on account of their supposed faulty structure, but very unnecessarily. Buffon supposed that its "existence must be a burden to the sloth." Cuvier fell into the same error. "Nature seems," he says, "to have amused herself in producing something imperfect and grotesque with disproportioned structure and inconvenient organization." But these mistakes arose from seeing the animal out of its natural surroundings. The sloth whose sluggish movements on the ground, where it can neither walk nor stand but drags itself along, obtained for it its name, is constructed for living in the trees, not on or among the branches as monkeys, but *under* them, and for this life its structure is admirably adapted. Its long fore-legs, enormous pelvis and in-turning wrists and ankles compel it when on foot to walk or crawl on the outer edges of its feet and on the outer knuckles of its hands with the claws bent inward and upward as a man on all fours might crawl resting on the knuckles of the little fingers with fists doubled up and on the outer edges of his foot—a position as awkward to him as natural to the sloth. But put the creature into a tree and let it hang from a limb and it is by no means a sloth. It can climb with fair speed though its usual pace is slow, and in the tangled South American forests can pass for miles from tree to tree without descending to the ground. Clinging by the long hind claws and by one fore-foot with the other it draws together the branches and foliage on which it feeds. In this position it is free from fatigue, as is the horse when standing. During sleep it rests in the fork of a tree rolled almost into a circle and clasps the trunk with its fore-legs, protected to a large extent by the color of its hair which resembles dry grass or moss. Mr. Waterhouse even asserts that it frequently sleeps suspended.

Its powerful claws are formidable weapons of defence. In danger the sloth throws itself on its back and seizing its enemy

attempts to crush it. In this way it has been known to strangle a dog while still held at arm's length.

Such are the sloths of the existing world. But those of the past—their ancestors—were animals of immense size and massive build. They combined in their structure several points not found in any single animal of the order at the present day—a usual fact in palæontology where the ancestor is less specialized than the descendant.

IV. *Fossils of this order.*

With a single exception all the extinct fossil sloths belong to the family of megatherians, and as might be expected they are found for the most part in South America, where the almost boundless pampas probably conceal countless multitudes of these monsters. For 900 miles what is now a waving sea of grass only a few feet above high-water level was one vast estuary of the rivers Parana and Uruguay wherein their carcasses were buried. In his "Journal of a Naturalist," Charles Darwin says:

"The number of the remains of these quadrupeds embedded in the vast deposits which form the pampas and cover the granitic rocks of Banda Oriental must be extraordinarily great. I believe a straight line drawn in any direction through the country would strike one of these skeletons or bones. They did not perish in the marshes or muddy river-beds of the present land, but their bones have been exposed by the streams cutting the deposits in which they were embedded. The whole area of the pampas is one wide sepulchre of these gigantic quadrupeds."

Of the huge extinct sloths, of which Mr. Darwin here writes, the megatherium was the earliest discovered, and is also the largest. In 1789, on the banks of the Luxan, about three miles from Buenos Ayres, and 100 feet below the surface, an almost entire specimen was dug up, and, of course, sent to Spain, where it was set up in the Royal Museum at Madrid. This is the original of the figure current in nearly all works on natural history. It was described by the great French naturalist, Cuvier—the founder of vertebrate palæontology—and by him named *megatherium Ameri-*

canum, but it has since been generally known by the name M. Cuvieri, given in his honor by Desmarest.*

A second skeleton was found in 1795, at Lima, and since then several others, partially complete, have been discovered, and sent to Europe. The model in the British Museum was constructed from the study of detached bones preserved there, and in the Hunterian Museum of the Royal College of Surgeons, and is the origin of the second current figure of this animal, which represents it with the right hand clasping the trunk of a tree—a position somewhat hypothetical.

This gigantic ground-sloth—for an animal of so massive proportions could not climb—measured 18 feet in length, and its bones are heavier than those of an elephant, the thigh-bone being three times as thick as that of the largest existing elephant. Its strength, as indicated by the ridges and crests, must have been enormous. It must, therefore, have sought its sustenance on the ground, and it was originally supposed to have lived on roots; "but, by a masterly piece of deductive reasoning, Sir Richard Owen showed that this great ground sloth lived on the foliage of trees as the existing sloth, but with this difference—that instead of climbing among the branches, it actually uprooted the tree bodily. In this task, the animal sat upon its huge haunches and its mighty tail, as on a tripod, and then grasping the trunk with its powerful arms, either wrenched it up by the roots or broke it short off, above the ground. Marvellous as this may seem, it can be shown that every detail of the skeleton of the megathere accords with the supposition that it obtained its food in this way." † (Lydekker's Manual of Palæontology, p. 1296.)

In thus seeking its food it would also find a use for its enor-

* Several facts, not easy of explanation, induce the writer to ask if this is not the same skeleton as that which confronts the visitor in the palæontological museum, in the Jardin des Plantes? The resemblance is strong. In that case, was it transferred from Madrid to Paris, during the occupation of the Peninsula by the armies of France during the Peninsula war? The story of the Mosasaurus of Mæstricht, is familiar to palæontologists.

† In connection with this point, it was formerly suggested by Sir Woodbine Parish, that these animals might have lived on the American aloe (*Agave Americana*), being quite capable of chewing its hard and spiny leaves. It may also be mentioned that the specimen of the mylodon described by Owen had had its skull twice fractured during life and healed. This, it has been suggested, may have been caused by the fall of a tree which the creature was tearing up.

mous claws which were probably employed to scratch away the earth from the roots, so as to render the overthrow of the tree more easy. There were four of these on each fore-foot and only one on each hind-foot, or ten in all, the outer toes being nailless. There were five teeth in the upper and four in the lower jaw on each side, or 18 in all.

Two species, at least, are known of this genus. The second member of this family of giants that came to light was *Mylodon robustus*, a species somewhat smaller than Megatherium, being only about eleven feet in length. This, also, was disentombed from the Pleistocene deposits of Argentina. It differs from the preceding in a few minor points, such as the less massive lower jaw and the shorter and lighter skull. What has been said above of the habits of Megatherium applies equally well to Mylodon. It was about as large and heavy as a rhinoceros.

The earliest skeleton of the Mylodon was brought to England, in 1841, by Sir Woodbine Parish, from the Salado river, Buenos Ayres, and described under the name of *M. robustus*, by Prof. Owen, in a magnificent quarto work. It was afterwards set up in the museum of the Royal College of Surgeons (of which Prof. Owen was then curator), and where it still stands. It is very nearly perfect. Another, almost equally complete, was set up about three years ago, in the British Museum at South Kensington. These two are, I believe, the only nearly perfect skeletons known.

Several other species have been found. They are *M. armatus*, the largest, from La Plata, *M. darwini*, brought by Darwin from Patagonia and *M. Harlini*—the type—from the Big-Bone-Lick in Kentucky. This last was the earliest specimen that came to light as far back as 1835, when a jaw-bone was described by Harlan (as *Megalonyx laqueatus*), and by Owen dedicated to him in 1841. For years no more of the animal was known than the single bone in the cabinet of the Lyceum of Natural History of New York. But a few more teeth and fragments of bone have since been discovered in South Carolina, Oregon, Missouri, Mississippi and Kentucky.

The pampas have also yielded the type of Skelidotherium (*leptocephalum*), also described by Prof. Owen, and of which a partial skeleton has been set up in the museum at Bologna, under the

charge of Prof. Capellini. This is the only specimen yet obtained aside from detached bones. A figure of this may be seen in Nicholson and Lyddeker's "Palæontology." The head is longer and thinner than in either of the aforementioned genera, and the feet, so far as known, indicate considerable difference. The whole animal is less massive and is as it stands about 9 feet long. Its discovery was announced by Darwin on his return from South America, and the bones which he brought home are in the museum at South Kensington.

Of Skelidotherium, about seven species have been named. But the member of this remarkable family which most closely concerns this paper is Megalonyx. Generally closely resembling the above it yet differs in some points of less moment such as the perforated humerus, the long interval between the first and second teeth. The already given description and habits of Megatherium and Mylodon need not be repeated.

The history of the known specimens of this animal is not less interesting than that of those already referred to. The earliest mention of it occurs in the proceedings of the American Philosophical Society, the parent of scientific societies in this country, and whose founder and leading spirit was Benjamin Franklin. Here, under date of August 19, 1796, occurs the following entry:

"Jefferson's letter to Rittenhouse (deceased) describing bones of extraordinary size found beyond the Blue Mountains, in Virginia, appearing to be of the tyger, lion and panther species, was read by Dr. Barton."

Again, at an adjourned meeting on March 10, 1797, occurs the entry:

"Jefferson's memoire on the discovery of certain bones of quadruped of the" —— blank space left, as if the secretary intended to enter the full title at a more convenient season which never came.

Also the following:

"*Resolved*, That this memoire be put into the hands of the Committee of Selection of Publication, and said company are instructed to employ a proper person to undertake and execute drawings of the several bones exhibited (*sic*) by Mr. Jefferson with his memoire and in it referred to.

"*Resolved*, That it is the request of the society to Mr. Peal he

may cause those bones to be put in the best order for the society's use."

The Committee of Publication consisted apparently of Dr. C. Wistar as chief, for as we further read:

"1799, March 1, Wistar's description of the bones of the unknown animal, referred to Dr. Shippen for examination."

And at the next meeting:

"Dr. Shippen reported Dr. Wistar's description of the bones to be very accurate. Publication ordered."

Thomas Jefferson was, at the date in question, the president of the society and an active member; and, when later, he became President of the United States, he did not lose his interest in scientific pursuits, being reëlected to both offices, and holding both for several years together till compelled by the pressure of political duties to resign the former.

The full title of the paper mentioned above, was "A Memoir on the Discovery of certain Bones of a Quadruped of the Clawed Kind, in the western parts of Virginia," and in it the author suggested the name Megalonyx, in allusion to the enormous claw, which was one of the most striking of the specimens. This was adopted by Wistar in his account; and when Dr. Harlan later and more fully described them, and, as he supposed, another species also, he conferred on the former the deserved specific name derived from that of the statesman who first made them known—Megalonyx Jeffersonii.

This first find was made in a cave in Greenbrier county, West Virginia, and consisted of a broken femur, a radius and ulna, three metacarpals, three claws and four other phalanges. They are now in the cabinet of the Academy of Natural Sciences at Philadelphia. Other bones belonging to the same find were carried away by different people and lost or placed in other museums and their history forgotten.

Besides these bones—the original and classical specimen of this great Edentate—there are in the same collection about 20 fragments of another young Megalonyx from Big Bone Cave in Tennessee, a humerus from Big Bone Lick, Kentucky, and a rib which is thought to belong to Jefferson's specimen, a skull, with about a score of bones and teeth, more or less perfect, from Mississippi; another skull and about 50 whole and broken bones from the

mouth of Canoe creek, in Kentucky, on the Ohio. These, with a few teeth and claws from various places, and now in different collections, constitute nearly all the material available for the study of Megalonyx. No pelvis has yet been found with the exception of a fragment or two.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Ninth Annual Report of the United States Geological Survey to the Secretary of the Interior, 1887-88. By J. W. POWELL, Director. pp. xiii, 717; with 88 plates and maps, and 61 figures in the text. (Washington, 1889.)

Though this volume relates to the work done during the fiscal year ending June 30, 1888, and the imprint bears date of the next year, it was distributed to the working geologists of the country so late as December, 1890. The first 200 pages contain the report of the director, and the administrative reports of chiefs of divisions, with a financial statement of the disbursements for the Survey during the year. So long delay in the publication has been due, probably, to the slow progress in printing the accompanying papers, which make up the remainder of the volume, namely: The Charleston Earthquake, by Capt. C. E. Dutton; The Geology of Cape Ann, Massachusetts, by Prof. N. S. Shaler; Formation of Travertine and Siliceous Sinter by the Vegetation of Hot Springs, by Mr. W. H. Weed; and Geology and Physiography of a portion of northwestern Colorado and adjacent parts of Utah and Wyoming, by Dr. C. A. White. A review of Dr. White's paper has been already given in our January number, and the other papers will be noticed later.

Lake Bonneville. By GROVE KARL GILBERT. pp. xx, 438; with a large folded map, 51 plates, and 51 figures in the text. (Monographs of the U. S. Geological Survey, vol. i, 1890.) The largest one of the many lakes which were formed during the Pleistocene period in the Great Basin, named lake Bonneville for the earliest explorer of its region, covered at its maximum stage an area of 19,750 square miles, lying mostly in northwestern Utah but extending also into the borders of Nevada and Idaho. It was about ten times as large as its present representative, Great Salt lake, which, having a mean hight of 4,208 feet above the sea, lies 1,000 feet below the highest of the ancient shorelines. The maximum depth of the Pleistocene lake was about 1,050 feet, while that of Great Salt lake, in its range from the lowest to the highest stage within the past forty years, is from 36 to 49 feet. The hydrographic basin of lake Bonneville comprised a fourth part of the Great Basin, whose total area is estimated to be 210,000 square miles; almost

another quarter was tributary to the companion, lake Lahontan, described in a previous monograph by Russell; and the remaining half of this arid region of interior drainage held some twenty-five smaller lakes, much exceeding, however, the saline lakes and playas to which they are now reduced.

Foremost among the conditions producing the arid climate of the Great Basin and of the peninsula of Lower California, as pointed out by Dutton, is the branch of the Kuro Siwa current which sweeps southward with a width of about 300 miles along our Pacific coast. At the north this current is warmer than the adjoining part of the ocean, and the warm winds blowing from it over Alaska, British Columbia, Washington, and western Oregon, are cooled by the land and precipitate their abundant moisture in copious rains; but as this current continues to lower latitudes it slowly loses its heat and on the coast of California is cooler than the oceanic area farther west, so that the winds crossing it are cooled and depleted of much of their moisture before reaching the land. In these latitudes, moreover, the heated land area during the greater part of the year condenses little or no rain from these winds, excepting on the high mountain ranges. Plentiful rains and snows fall on the lofty Sierra Nevada, extending 400 miles along the west side of the Great Basin, into which the air currents then descend, thirsty for evaporation.

But the shore-lines and lacustrine beds of lake Bonneville, like those of lake Lahontan, demonstrate that twice the Pleistocene climate of this region became more humid, though to less degree than the present climate of the eastern half of the United States. The humid epochs were divided by a long interval of aridity, in which, as Mr. Gilbert has shown, lake Bonneville was perhaps wholly evaporated, its soluble mineral matter becoming intermingled and covered with playa silts, so that it could not be redissolved by the water of the lake during its second rise, which may have been nearly fresh. The first great rise of lake Bonneville, lifting its level to within 90 feet of the lowest point of the enclosing water-shed, is recorded by numerous beaches, marking the oscillations of the lake level under the varying influence of secular climatic changes, and by a thick lacustrine deposit of yellow clay. A long interlacustrine epoch is known by overlying alluvial gravel and sand. The second rise of the lake reached the level of overflow, apparently after the water surface had been long held within five to twenty feet below that level, forming a widely spread deposit of white marl, and the well defined highest beach ridges and eroded cliffs, which Gilbert names the Bonneville shore-line. The time required for the great amount of wave-work at this level would be made possible by long continued underground drainage from the lake through the alluvial deposit of Cache Valley, over which a slightly higher rise of the lake finally gained a superficial outflow to the Columbia river, and then rapidly cut a channel 375 feet deep in the alluvium to a sill of limestone. At this lower level, marked by the Provo shore-line and deltas, the lake was held for a long

time, perhaps occasionally interrupted by dry climate and fall of the water, too low to maintain its outlet.

Glaciers descending the cañons on the west front of the Wasatch range attained their maxium extent, pushing their moraines into lake Bonneville, during the time of formation of the Provo shore-line. From these moraines and from those of Sierra Nevada extending into the Pleistocene area of lake Mono, the glaciation of the Cordilleran region is known to have been contemporaneous with the epochs of humid climate and extension of lakes in the Great Basin, the interlacustrine epoch being attended probably with a nearly or quite complete departure of the glaciers and ice-fields on the mountains.

Inquiring what were the causes of these great climatic changes, the author shows that a bodily uplift of the entire district, including the Great Basin and the adjacent mountains, would favor the growth of both lakes and glaciers, while conversely they would be diminished by depression of the district. Evidences of Pleistocene elevation of the land, corresponding to the glacial and lacustrine epochs, are found in the deeply submerged channels near Cape Mendocino, which have been described by Prof. George Davidson of the U. S. Coast Survey. On the other hand, proofs of Pleistocene depression, referable probably to the time of temporary retreat of the glaciers and lowering or desiccation of lakes in the Great Basin between their two stages of high water, are supplied by the marine terraces of the Columbia and Frazer basins cited by Gilbert, and by the Pleistocene beds of the Californian coast recently described by Dall as rising gradually toward the south until at Monterey and southward they are about 600 feet above the sea level.

Frequent eruptions of basalt have occurred within the area of lake Bonneville, the earliest belonging to the Tertiary era, long before the existence of the lake, others successively to the time between its first and second maximum stages, to the date of the Provo shore-line, and to the recent epoch since lake Bonneville was reduced to the Great Salt lake.

Uplifting of the Wasatch range is shown to be still in progress by post-Bonneville fault scarps. Independent of these, a deformation of the area of the Pleistocene lake has taken place, by which its central portion is uplifted about 170 feet in comparison with its boundary; and this deformation of the planes of the old shore-lines is regarded by the author as probably due to the drying away of the lake, the removal of this weight of water being attended by viscous distortion of the earth's crust.

The last chapter of this valuable and very interesting monograph discusses the age of the Equus fauna, which at its type locality is contained in lake beds that are correlated with the uppermost of the Lahontan and Bonneville beds; and the conclusion is reached that this fauna, previously called late Pliocene, is instead to be referred to a late stage of the Pleistocene or Glacial period.

Preliminary Account of the Fossil Mammals from the White River and Loup Fork formations contained in the Museum of Comparative

Zoology. BY W. B. SCOTT and HENRY F. OSBORN. Although the first part of this paper was published in September, 1887, the contents of both parts may here be conveniently noticed, as the paper has been but recently concluded. As in other of their joint writings, the authors have divided their labor, the treatment of the *Carnivora* and *Artiodactyla* being by professor Scott and that of the *Perissodactyla* by professor Osborn.

Part I, constituting No. 5 of vol. XIII of the Bulletin of the Museum of Comparative Zoölogy at Harvard College, treats of White river Miocene mammals from Nebraska and Dakota.

The skeleton of *Hoplophoneus* is very fully described and is illustrated with a restoration. *Oreodon gracilis* is found to possess a pollex, thus removing any suspicion that Prof. Scott's description of a pollex in *O. culbertsoni* may have been based on a case of abnormal polydactylism. A skull and a hind foot, supposed to pertain to a single species, and referred to the European genus *Hyotherium*, yield the first record of this genus from America and are described under the name *Hyotherium* (?) *americanum*. A study of the dentition and skeleton of *Leptomeryx* leads the authors to consider this genus, with Schlosser, as a true traguline, as opposed to Rütimeyer's view that it is more nearly allied to the *Camelidæ*. Illustrated comparative studies of the skulls of *Menodus coloradoensis*, and the new species, *M. tichoceras*, *M. dolichoceras*, and *M. platyceras*, and a restoration of the skeleton of *M. proutii* are given. The genus *Metamynodon* is described as a successor of the middle and upper Eocene genus, *Amynodon* and of about double the size and strength of the latter, equalling in size the largest of modern rhinoceroses and representing a line distinct from that of *Hyracodon*, *Aceratherium*, or *Diceratherium*. Portions of the skeleton of *Aceratherium* are described. The resemblance of *Hyracodon* to *Hyrachyus* and its analogies with the horse are mentioned, and two new species of the former genus, *H. planiceps* and *H. Major* are described.

Part II of this paper, constituting vol. XX, No. 3, of the above mentioned Bulletin, bears date of November, 1890, and is devoted especially to Loup Fork mammalia from Nebraska and Kansas. The following are the more important observations brought out in it: The discovery of the mandible of *Ælurodon hyænoides*. The discovery of a femur closely like that of a lion, but indicating an animal larger than and distinct from *Smilodon*. The determination of the foot-structure of *Merycochœrus* (previously partly effected by Cope), which is found to be closely similar to that of *Merychyus*. A very complete description of the manus and pes of *Blastomeryx*, the genus being regarded, with Cope, as being in the ancestral line of the distinctively American deer. An account of the dentition and a description and restoration of the skeleton of *Cosoryx*, which is regarded as probably having its ancestry among John Day Miocene forms of *Blastomeryx*, and (with Cope) as itself ancestral to *Antilocapra*. Observations on the molars of the equine series. Observations on the manus and pes of *Aceratherium*.

A description and restoration of the skeleton of *Aphelops fossiger*. A discussion of the homologies of the elements of the molar teeth in rhinoceroses. A study of the brain-characters of *Mesohippus* and *Aphelops*, including a comparison of the brain-casts of *Aphelops*, *Aceratherium* and *Ceratorhinus*, from which the conclusion is drawn that "the steady brain-growth of the ungulates during the Eocene and early Miocene periods reached its highest point in some families of the later Miocene, and was followed by a degeneration." The announcement of *Chalicotherium* from the Loup Fork of Nebraska and the probable identification with it of *Moropus elatus* Marsh, from the Loup Fork of Kansas.

This important contribution to the knowledge of North American Tertiary Mammalia is the forerunner of "a memoir upon the Cambridge collection of Miocene Mammals, which is now in preparation."

Classification of the glacial sediments of Maine. GEORGE H. STONE. (Am. Jour. Sci. Vol. xl, August, 1890.—This paper notes the features of the drift in the central and southern portions of Maine, and in particular those modifications of the glacial deposits which are due to the presence of the waters of the Atlantic ocean when at a higher level than the present.

1. *Isolated Kames*, viz., those short ridges so distant from all other glacial sediments that if they had any other cotemporary correlative sediments they are not known. They are found in all parts of Maine except possibly in the extreme north. They are supposed to have been formed in channels in the glacier.

2. *Hill-side Kames*, found on the south slopes of rather high hills, expanding toward the bottom into a plexus of reticulated ridges, of coarse sediment above and finer below, as if the depositing river entered a body of still water, or in some way lost its carrying power. These are found above the level of 230 feet.

3. *Kames ending in marine deltas*. This is shown by the horizontal transition of the gravel of the kame first into sand and then into clay containing marine fossils.

4. *Kames ending in lacustrine deltas*. These are found only above the contour line of 230 feet above sea-level. These exhibit the same horizontal sorting of the sediments as the marine deltas (No. 3) but they do not contain marine fossils.

5. *Massive Kame-plains*. These are extended gravel plains mostly found below 230 feet formed by glacial rivers carrying abundant glacial debris and not checked in their course by any large body of open water so as to allow of the dropping of their finer sediment.

6. *Discontinuous Kame systems*. These are in linear series separated by intervals of varying length. These fragments of ridges are separated by expanses of unmodified till, and are almost exclusively confined to the coastal region below 230 feet above the sea. There is, according to Prof. Stone, a general law prevailing; viz., that at about 230

feet above the sea there is a maximum development of glacial sediments, and that they diminish in amount in opposite directions from this line, the gravels in particular becoming more and more discontinuous in approaching the coast.

7. *The osars.* These are longer two-sided gravel ridges some of them extending more than 100 miles northward. At their southern extremities, about the level of 230 feet, they break up into non-continuous kames (No. 6) and finally disappear in marine deltas.

8. *Broad osars or osar plains.* These are simply local expansions of the osars (No. 7) into plains due to the widening of the ice valley in which the glacial river flowed. Prof. Stone regards the rivers, at these places, as having been probably open upward to the sun, but leaves us to infer that in general he considers the river that produced the osar proper to have been subglacial. These ósar plains when later cut down by streams show the origin of the terracés composed of glacial sediments that accompany so many valleys in New England.

9. *The reticulated kames.* This is a "plexus" of ridges, containing kettle holes, found at the landward ends of the marine and lacustrine deltas. In general they appear to be only a feature of the deltas, but some are found unconnected with deltas. They are between 230 and 600 feet above the present sea level, mostly in rather broad valleys and in level regions. They seem to be due to a concentrated action, or to a duplicated effect of several glacial streams entering the general valley at these points, and also to a gradual shifting of the course of the streams near their mouths due to the gradual recession of the ice margin.

10. *Osar border-clays.* This is a broad-channel deposit of finer materials, due to the same conditions and forces.

11. *Frontal plains.* These are plains of sediment brought by glacial streams down to the extremity of the glacier and then spread subaërially over the land in front of the ice. It is hence a "valley drift" of glacial date.

12. *Much of the so-called valley drift,* or thick sheets of alluvium which covers the larger valleys of New England, is not considered as the result of post-glacial erosion of the till by ordinary atmospheric forces, but rather a frontal-plain deposit which accumulated rapidly after the ice had retreated to some distance northward but was yet able, in its later dissolution, to swell all the streams. The fine material he considers may have been largely of super-glacial posé before it left the ice.

Prof. Stone has given very careful and thoughtful attention to the coastal deposits of Maine, as correlated with the glacial epoch, and he has added much that will enter into the solution of questions that are very prominent touching the nature and origin of a series of beds lately named the "Columbia formation" by McGee, and their relations to the "Champlain" clays of Hitchcock as well as to the Laurentian and Algonquin of Desor.

LIST OF RECENT PUBLICATIONS.

1. *State and Government reports.*

The palæozoic fishes of North America. By John Strong Newberry. Monograph XVI. U. S. Geol. Survey, Quarto, pp. 228, 53 plates of fossil forms.

The Building-stone of New York. John C. Smock, Bul. N. Y. State Museum, Vol. II, No. 10, 1890.

Mineral Resources, U. S. 1888. David T. Day, Washington, 1890.

Bulletins U. S. Geol. Survey, viz: No. 58, The glacial boundary in Western Pennsylvania, Ohio, Kentucky, Indiana, and Illinois, Geo. F. Wright, (Reviewed in the GEOLOGIST, Vol. VI, p. 390); No. 59, The gabbros and associated rocks in Delaware. Frederick D. Chester; No. 60, Report of work in the department of Chemistry and Physics, in 1887-8, F. W. Clarke; No. 61, Contributions to the mineralog y of the Pacific coast, Melville and Lindgren; No. 63, A bibliography of North American Crustacea, from 1698 to 1889, including a list of North American species and a systematic arrangement of genera, Anthony W. Vogdes; A report of work done in the division of Chemistry and Physics, mainly during the year 1888-89, F. W. Clark; No. 66, On a group of volcanic rocks from the Tewan mountains, New Mexico, and on the occurrence of primary quartz in certain basalts, J. P. Iddings.

Tenth annual report of the California State Mining bureau, William Irelan, Jr., Sacramento, for the year 1890. Octavo, pp. 983, accompanied by a case of six colored maps and diagrams. Illustrated by numerous plates and figures.

Geolog. and Nat. Hist. Surv. Minnesota, Eighteenth report, for 1889. 8vo, 234 pp., Minneapolis.

Ninth annual report of U. S. Geol. Surv., 1887-8, 4to, pp. xiii. and 717.

Lake Bonneville, by G. K. Gilbert. Monograph, No. 1, U. S; Geol, Surv., pp. xiii, and 438.

2. *Proceedings of Scientific Societies.*

Appalachia, Vol. VI, No. 2, contains: Ascent of the volcanoes Nantaisan, Asama-yama and Nasu-take, W. J. Holland; The great Smoky mountains and Thunderhead peak, Frank O. Carpenter; The San Juan mountains, Frederick H. Chapin; An ascent of Sierra Blanca, Charles G. Van Brunt.

Proceed. Phil. Acad. Nat. Sci., Part II, Apr.–Sept., 1890, contains: Synopsis of American Carbonic Calyphæidæ, Chas. R. Keyes (Reviewed in the GEOLOGIST, Vol. VI, p. 248); Hippotherium and Rhinoceros from Florida, Joseph Leidy; Mastodon and Capybara of South Carolina; Barometric observations among the high volcanoes of Mexico, with a consideration of the culminating point of the North American continent,

Angelo Heilprin ; An account of the Vincelonian volcano, Benj. Sharp.

Bulletin of the Santa Barbara society of Natural History, Vol. No. 2.

Iowa Cin. Soc. Nat. Hist., Oct., 1890, contains : New and little known American palæozoic ostracoda, E. O. Ulrich ; Concerning a skeleton of the great fossil beaver, Castoroides ohioensis, Joseph Moore.

Transactions, N. Y. Acad. Sci. May–June, 1890, contains : By Geo. F. Kunz, descriptions and notes on the following meteorites, Kiowa, Bridgewater Burke Co., N. C., Blount Co., Ala., Rutherford Co., N. C., Haywood Co., N. C., Winnebago Co. Iowa; The change in our climate and the cause, E. B. Dunn.

3. *Papers in Scientific Journals.*

Canadian Record of Science, Vol. IV, No. 3, *July*, 1890. The Quebec Group of Logan, Sir William Dawson.

Am. Nat., *Dec. No.*, The naticoid genus Strophostylus, Chas. R. Keyes.

School of Mines Quarterly, *Nov.* Outbursts of gas in metalliferous mines, Barnett H, Brough : Examination of mines, H. S. Monroe.

CORRESPONDENCE.

Was Lake Iroquois an Arm of the Sea? During the meeting of the Geological Society at Washington, I learned from professor Spencer that I had confused his lake Iroquois with his lake Algonquin, in my note to your journal a month ago. If I now understand him correctly, it was lake Algonquin that stood at the higher level, uniting the basins of Erie and Ontario; while lake Iroquois was the reduced body of water in the Ontario basin, after the separation of Algonquin into two parts. Professor Spencer's contention is that Iroquois was at sea-level, and not held up above sea-level by a barrier of ice in the lower St. Lawrence valley. My note should therefore have referred to the outlet of the Iroquois waters past Rome, N. Y., down the valley of the Mohawk. Mr. Gilbert's observations seem to prove the existence of such an outlet, and I wished to know how professor Spencer explained it on the supposition that Iroquois was an arm of the sea.

But this question is answered in a paper by professor Spencer in the American Journal of Science for December, to which he referred me and in which he says: " Even the coincidence of the shallow and small channel, discovered by Mr. Gilbert, connecting the Iroquois waters with the sea by the Mohawk valley, or of the broader and lower valley of lake Champlain, does not prove the necessity of a former barrier across the St. Lawrence valley, any more than the narrow channels among the

gigantic islands north of Hudson bay would prove the former presence of a dam holding in the waters of that bay, were the whole country elevated" (p. 450). Although I have done no field work worth mentioning on the shore-lines of these ancient lakes, the question of the origin of the lakes has interested me greatly, and I have for some time regarded them as most probably the combined result of pre-glacial erosion, glacial excavation and postglacial warping, with perhaps some assistance from local glacial depression, as suggested by Chamberlin. The share that warping may have had in this result depends in part on the former altitude as well as on the altitude of the continent, and professor Spencer claims to have shown that the continental altitude at a certain time may be determined by means of the old shore-lines, which he interprets as having been made on the margin of a bay, and therefore at sea-level. Hence the interest attaching to his explanation of the outlet by the Mohawk valley. The comparison that he makes between Iroquois and Hudson bays is in one respect perfectly fair, but there are four considerations that appear to me to invalidate the comparison completely. The first is the close correspondence of the Iroquois shore-lines with the level of the Mohawk passage; this correspondence would be of accidental origin if Iroquois were a bay; but it would be an essential feature if the passage were an outlet. Second, if Iroquois were a bay, the shore-lines should be found at the same level, except for their subsequent warping, on both sides of the passage; and as far as observation goes, no Iroquois shore-lines are reported on the eastern or outlet side of the Mohawk valley. Third, the Mohawk valley shows signs of former occupation by a river of much larger volume than the present Mohawk. Fourth, it is not only in Iroquois that the correspondence in the levels of old shore-lines and outlets is found; the same correspondence is known to have occurred in the case of the expanded shores of Erie, when it rose to the level of the Maumee-Wabash passage (Spencer's Algonquin); and still better in the case of lake Agassiz, when its waters rose so as to cross the pass between Big Stone and Traverse lakes, by which its basin was separated from the Minnesota-Mississippi valley. Large post-glacial lakes with outlets over low passes appear therefore to have characterized a recent epoch in our history. Arms of the sea were very likely expanded at about the same time, but they did not reach Iroquois or Agassiz.

The question then remains, by what barrier were these lakes held up at their other end; and the answer generally given is, by the retreating ice-sheet. It is eminently proper that we should be slow to accept so curious an explanation; it is certainly true that existing glacial lakes are small and evanescent; and it is very questionable what thickness of ice would be needed to hold in the waters of Iroquois and its fellows; but at present, we must regard these bodies of water as lakes, and no explanation for the lakes has yet been suggested that can displace the glacial hypothesis. W. M. DAVIS.

Harvard College, Cambridge, Mass., Jan. 3, 1891.

PERSONAL AND SCIENTIFIC NEWS.

PLEISTOCENE PAPERS AT THE MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA, WASHINGTON, DEC. 29-31, 1890.—Prof. J. W. Spencer's paper, read Monday afternoon, Dec. 29, on "Post-pliocene Continental Subsidence," set forth the evidences afforded by fiords and submarine valleys, like that of the Hudson, that the greater part of North America has been depressed 3,000 feet, more or less, since the Pliocene period. On the Atlantic coast northward to New York and Massachusetts, and on portions of the shores of the eastern provinces of Canada, this subsidence is still going forward, as shown by stumps of trees standing where they grew but now covered by the sea. But the region about Hudson bay, according to Dr. Robert Bell's observations, is now being elevated, and professor Spencer believes that the postglacial elevation of the region of the Laurentian lakes, which in places has amounted to not less than 500 feet, is also still slowly in progress.

Monday evening Prof. W. M. Davis presented "Illustrations of the Structure of Glacial Sand Plains," a series of excellent stereopticon views, from photographs by himself and H. L. Rich, of small sand plains of stratified drift, with their associated esker ridges of gravel and sand, situated in the vicinity of Boston. The formation of these deposits was referred to the action of streams produced by the melting of the ice-sheet, the materials, which were rapidly deposited, having been englacial drift enclosed in the lower part of the ice.

In the same evening session, Mr. I. C. Russell gave a very interesting account of his explorations during the past summer, with Mr. Mark B. Kerr, on Mt. St. Elias and the mountains extending thence fifty miles southward to Yakutat bay. A large map of the mountain ranges and glaciers was exhibited, showing valley glaciers on the south, terminating in Disenchantment bay; but from this bay and Yakutat bay northwestward the valley glaciers merge into a terrace-like ice-field, named by Russell the Piedmont or Malaspina glacier, ten to twenty miles wide and more than fifty miles long, bordering the coast. The surface of this great ice-field in its seaward portion is covered with drift to depths varying from a few inches to several feet; and on this superglacial soil a profuse growth of flowering plants springs up in many places during the short summer, while other parts of the same tract are clothed with a coniferous forest. Rivers flow through the Malas-

pina glacier, partly in subglacial courses, partly in cañon-like channels, which are often underlaid by ice. A large stream, of which lantern views were shown, issues from an ice-tunnel and after flowing a considerable distance in a channel open to the sky disappears in another ice-tunnel, about 150 feet wide and 50 feet high.

The age of the shales and sandstones which form Mt. St. Elias and the neighboring ranges is found to be late Pliocene or more probably Quaternary. Plentiful marine shells occur in these strata up to an elevation of 5,000 feet on the Hitchcock range and Pinnacle pass, the species being the same that now inhabit the sea-shore of Alaska. The mountains have been formed by profound faulting, with upthrusts and tilting; and the pyramidal sharp peak of St. Elias is found to be the uplifted corner of a great orographic block. There is no evidence of general glaciation upon the highest ranges, but the valley glaciers have been 1,000 feet thicker than now. From their known recession at Disenchantment bay within the last hundred years, Mr. Russell concludes that the maximum extension of the Alaskan glaciers was attained only a few hundred years ago.

Tuesday evening Mr. George F. Becker read a paper on "Antiquities from under Tuolumne Table Mountain, California." The authenticity of the discoveries of stone mortars and pestles, spear heads, human bones, and the famous Calaveras skull, in the deep auriferous gravels of California, capped by lava-sheets, seems to be fully established. Mr. Becker therefore thinks that these gravels are probably no older than the glacial drift of other parts of North America and Europe in which the earliest other traces of man's existence are found. The uplifting of the Sierra Nevada and changes in the courses of streams there were apparently in part or wholly early Pleistocene; and the much later glaciation of the Sierra Nevada is probably to be correlated with the second Glacial epoch of the northeast part of the continent, or indeed may have occurred since the departure of the northeastern ice-sheet.

This was followed by a display of stereopticon views from Idaho and California, by Prof. G. F. Wright, with description of the Pleistocene lava deposits of the Snake river valley. The special interest of this paper related to the image found in an artesian boring at Nampa, Idaho, which is figured, with notes of the geologic section, in the GEOLOGIST, vol. iv., p. 387, Dec., 1889. Professor Wright also gave additional statements confirming the discoveries of human implements in the lava-capped gravels of Table mountain, California.

Wednesday afternoon Prof. Edward Orton spoke of the recent discovery, less than two weeks before the meeting, of many of the bones of a Megalonyx jeffersonii Harlan, in central Ohio, during the excavation of a ditch for drainage. Several of the bones, in-

cluding a femur, all in a very perfect state of preservation, were exhibited before the Society; and professor Orton stated that further exploration of the locality, when permitted by return of mild weather, will probably recover additional parts of the skeleton. It was found only a slight depth beneath the surface, in a postglacial marl bed. The surprisingly late extinction of this and other gigantic Pleistocene mammals, after the culmination of the Glacial period, was noticed as very difficult to be explained.

The next paper was by Mr. Warren Upham, on the "Glacial Lakes of Canada," formed during the recession of the ice-sheets which were temporary barriers across hydrographic basins now drained toward the north. Lake Agassiz, in Minnesota, North Dakota and Manitoba, stretching north over the present sites of lakes Winnipeg and Manitoba, was described as the most extensive of these lakes. At the same time the great lakes now outflowing by the St. Lawrence were held at higher levels than now, as shown by their old shore lines; and during later stages of the glacial recession great glacial lakes were formed in the southern part of the basin of James and Hudson bays, outflowing southward over the continental water-shed at its lowest passes near Kenogami and Missinaibi lakes to lake Superior, and by lake Abittibi to the Ottawa. From the descriptions of the drift deposits along the eastern base of the Rocky mountains and on the Peace river, given principally by Dr. G. M. Dawson, of the Canadian Geological Survey, Mr. Upham claimed that the eastern or Laurentide ice sheet and the western or Cordilleran ice-sheet became confluent during the culmination of the second Glacial epoch, the western ice probably wholly enveloping the Rocky mountains near the Peace river, where they rise only 3,500 feet above the adjoining country and about 6,000 feet above the sea. The southern border of the confluent ice at that time appears to have reached to Wood mountain, the Cypress hills, and the sources of Milk river, in southern Assiniboia and Alberta; and the ice-sheet of British Columbia, as determined by Dr. Dawson, covered isolated mountains 5,000 to 7,640 feet above the sea.

In discussion of this paper, Dr. Dawson pointed out the difficulty of believing that the great plain country between Manitoba and the Rocky mountains was ever covered by an ice-sheet, instead of which he attributes the deposition of the drift there to floating ice during a marine or lacustrine submergence.

Lack of time prevented the reading of several other papers on Pleistocene geology, probably not less important, whose authors were absent; but, with the foregoing, these will in due time appear in printed form.

Dr. W. Clark, of Berea, O., has been in the field again and has met with his accustomed success in discovering fossil fish. His previous work in this direction will be fresh in the mind of

all fossil ichthyologists. His gigantic Titanichthys and many other specimens from northern Ohio enrich the collection of Dr. Newberry at Columbia College, New York.

Dr. Clark has now an entire specimen of *Cladodus* resembling the one described. It is nearly six feet long and almost complete. From tip to tip of the expanded fin is a distance of twenty-one inches. The teeth are shown in a row but are not yet freed from the matrix. The fins are not set at the same angle to the body as in the specimen figured by Newberry as *Cladodus kepleri.* Each measures nine and a half by six and a half inches. It also differs from that species in the form of the head, teeth, fins and jaw, and he claims it as a new species.

Another specimen so far as it is at present discernible indicates a new genus. The head is remarkably round, measuring five by four and a half inches, and there is a constriction between it and the body. Its length over all is about twenty-six and a quarter inches.

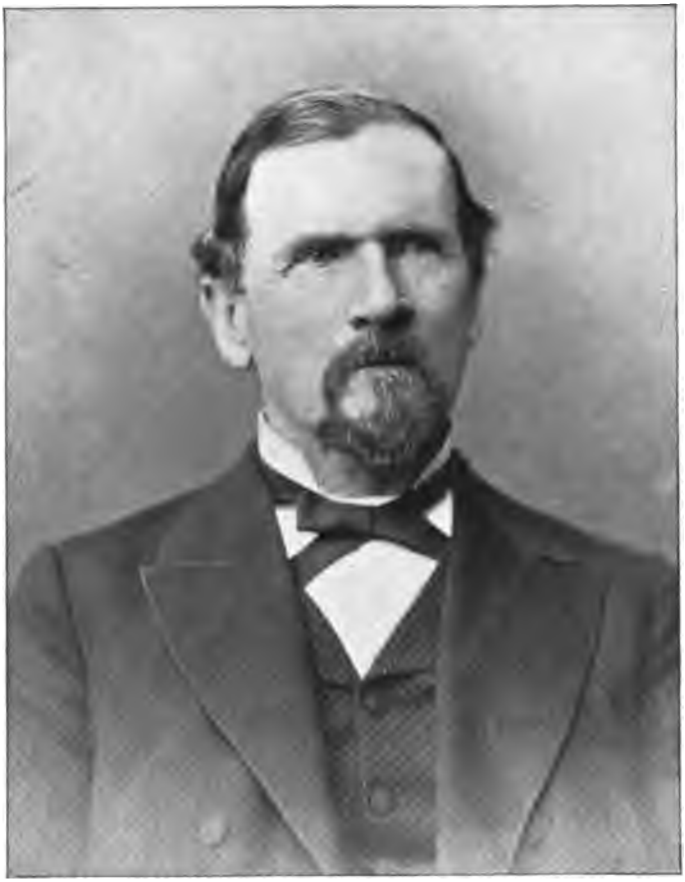
A remarkable mandible of *Titanichthys*, straighter than any previously found, and twenty-three inches long by three and three-quarters inches deep, is another interesting object in the collection as indicating a new species of the genus.

He has also extracted from the matrix and put together with much skill a perfect jaw of *Dinichthys*, only ten inches long by one and one-eighth deep, and differing from any yet known in its exceedingly slender proportions and different structure. The cutting edge of the dentary bone terminates in a thin tooth strongly contrasting with the massive ending of the species previously described.

But probably the most interesting of all Dr. Clark's recent discoveries, is a plate of an armor-clad fish from the Cleveland shale, resembling nothing yet described but recalling to some degree the general likeness of *Glyptaspis* as figured by Newberry in his late volume on palæozoic fishes. But instead of being thick and overlapping, this plate is thin and shows no bevelled edges. The sculpture is also very fine and delicate. It measures eleven and a half by five inches.

Dr. Clark has also the head of a *Titanichthys* that promises to furnish some new information on the structure of the heads of our placoderm fishes, and which he promises soon to make public. He thinks that the classification of some of the fishes of the Cleveland shale is to say the least a little "mixed," and that from the material in his possession and his explanation of the same he will be able to establish his views.

THE MESSAGE OF GOV. FRANCIS, OF MISSOURI, commends the geological survey of that state in its plan and progress, and asks the Legislature to make increased appropriation for its support and continuance.



James Macfarlane

THE

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JAMES MACFARLANE.

By I. C. WHITE, Morgantown, W. Va.

The subject of this sketch, so well known to the geologists of America, was born at Gettysburg, Pa., September, 2nd, 1819, and died of heart failure, at Towanda, Pa., October 12th, 1885.

Connected by kindred ties with the best families of the Cumberland Valley, and descended from a race proverbial for energy, thrift, and untiring industry, he was born rich, not in material things, but in that far superior endowment, of clear intellect, robust body, sturdy character, lofty aspirations and unconquerable will power, which characterizes the Scotch-Irish people.

Happily gifted by nature with a wealth of generous and kindly sympathies, Mr. Macfarlane went forth from his Alma Mater, Pennsylvania College, in 1837, fully equipped for victory in life's struggle.

Upon his record as a successful engineer of the North Branch Canal, a leading member of the bar at Towanda, the successful coal operator and railway builder, who opened up and developed the celebrated Barclay Mountain Coal Region, we cannot dwell, except to say that his ceaseless activity and tireless devotion to duty rendered him eminently successful in all his business ventures.

Of philosophic mind, a close and keen observer, his experience as a coal operator gave him the opportunity to collect and elaborate the data which he embodied in that very mine of useful information, as well as of popular scientific instruction, "The Coal Regions of America." This justly famous work met with such a

hearty reception by the general public, as well as by geologists in particular, that its author was encouraged to undertake the preparation of a volume for the latter's especial benefit, and the appearance of "An American Geological Railway Guide," fresh from his pen, in 1879, was hailed by geologists everywhere, as a boon of greatest value. This book, so unique in conception, and happy in execution, put all geologists under a heavy debt of gratitude to the author whose busy brain and hand had done so much for them. The amount of labor involved in the preparation of this little volume, can only be properly appreciated by those who have undertaken similar work.

The edition was soon exhausted, and in 1883 Mr. Macfarlane, in response to an appreciative public, began the preparation of a new and greatly enlarged volume of the "Guide," adding many novel and useful features. While in the midst of this labor the "dread summons" came suddenly, almost without warning, and the busy life was ended.

The two celebrated works just mentioned entitled Mr. Macfarlane to a high place among the contributors to the advancement of the science of geology; but they do not constitute the whole of his work for geology. His articles on "Coal," in Appleton's Encyclopædia and Gray's Atlas of Pennsylvania, "On the Formation of Cañons," in Science, August, 1884, and on "The Earthquake at New Madrid," at the Minneapolis meeting of the "A. A. A. S.," all attest the true scientific spirit as well as the geological ac umen of the author.

Some of his best work for geologic science was of the kind that is of great importance, but often overlooked. He was really the father of the bill which inaugurated the second geological survey of Pennsylvania, and largely through his labors and influence, were obtained the legislation and necessary appropriations which carried that vast work forward to such splendid results. A member of the Board of Commissioners of the survey from the beginning, he labored unceasingly in its interest, and probably did more than all others combined, to overcome popular prejudice against appropriations for such purposes. At the meetings of the Board he was the first to come, and the last to leave, and his practical knowledge of men, and good business qualities, combined

with his accurate geological knowledge, were of invaluable service to the survey.

Of the most kindly, sympathetic and appreciative nature, he also did much for geology in the words and acts of encouragement he always freely gave to the tyros in this science. Every new idea was welcomed, and was sure of a careful and judicial hearing at his hands.

The following tribute to his memory, by the Reporter-Journal of Towanda, in its issue of October 15th, 1885, so fittingly describes Mr. Macfarlane as a man and a citizen, that it finds an appropriate place here:

"No man, perhaps, in our community, will be more missed in the place of his home, and certainly none whose death will be so generally mourned abroad. His busy life brought him in contact with leading business men of this and adjoining states, and with men prominent in letters and science the country through. No man of our town had so wide a circle of acquaintance, and none, we may safely assert, had attained so eminent a place among the scholars and scientists of the land. By all his death will be long and sincerely mourned. But here, in Towanda—his home, where he was best known by his neighbors and fellow-townsmen, all of whom were his friends and to all of whom his death comes with the shock of a personal bereavement, will his death be longest and most deeply felt. For years he has gone out and in among us. His familiar form, his cheery voice, his genial manners and kindly words have been a part of our lives—a help, a very comfort and inspiration. His life, although crowded with work as very few lives are, was not given wholly to study and research. The demands of family and friends were paramount, and work was never so pressing that he could not put it aside to devote himself to them. In the social circle he was a leading spirit. His gentle manners, his ready wit and kindly humor, joined to a mind stored with riches gathered from every department of literature, made him the prince of entertainers, and the best of companions. In the circle of kindred spirits where he was wont to meet from time to time, there is a vacancy that cannot be filled."

"The death of such a man is a loss to our community—a loss which no man may measure. In projects tending to the material improvement of our town he was foremost. It was his far-

sighted sagacity that planned, and his indomitable will that helped to completion, the railroad that tapped the hidden wealth of Barclay mountain. He it was who has done so much since to develop the coal industry at other points in that region. The cause of education, religion, every deserving charity, found in him a liberal patron—a ready and efficient helper. His hand was in every good work. Very often it was unseen and unknown, but it was not the less helpful. The last act of his life was an act of charity. Many hearts whose load he has lightened on life's weary pathway, will hear of his death with deep and abiding sorrow."

"But while we count the loss that has come to many of us with such benumbing force, let us not forget the gain—the profit of this busy life. One of the sublimest, as well as the most practical solutions of the problem of life, is that which regards it as a system of producing, and of man as a producer, who, if his life work has been faithful and active, leaves behind an addition to the common stock of the world's goods, which, first or last will be distributed for the benefit of the human race. The broadest and best moral to be drawn from our toil is included, so far as it relates to this world, in the duties and offices and end of the toil itself; in the good it drops."

So it happens that the life of a self-made man, like James Macfarlane, who has just passed over to the great majority of men of toil, is filled with example for profit. Beginning at the foot of the ladder, he came when young, to our town, not endowed with the capital of wealth, but with the capital of brain, with honest intention, a quick eye for business, a ready hand for his work, and unswerving and unchangeable integrity. These were the qualities which he wrought into his accomplishments. He dies, not yet full of years, but leaving behind more material monuments of his industry than many great rulers, and more than all else, an example for the young men of this country, which will not soon be lost. He has left us a sign by which men may conquer, and deserve to conquer in the battle of life, and win a victory, not for themselves alone, but for their kind."

> "His life was gentle; and the elements
> So mixed in him, that Nature might stand up
> And say to all the world, 'This was a man.'"

Mr. Macfarlane was married in 1847, to Miss Mary Overton, of

Towanda, who survived her devoted husband only three years. Six children, three sons and three daughters, were the fruit of this happy union. Their names according to age are as follows:

Edward O., Towanda, Pa., Superintendent of Barclay R. R. & Coal Co., and President Citizen's National Bank.

Ella L., Wife of William Little, Esq., Towanda, Pa.

Graham, Civil and Mining Engineer, Louisville, Ky.

May C., Wife of E. J. Angle, Esq., Towanda, Pa.

James R., Attorney at Law, Pittsburgh, Pa.

Eugenia H., Towanda, Pa.

It is to the youngest son, James R. Macfarlane, that geologists owe the completion of the second edition of the "Guide." Probably none but the writer, and a few others, know under what great difficulties this volume was prepared. The death of the father had left all except the first portion in an unfinished condition. Yet, at a great sacrifice of time and money, the young barrister, just starting in life, undertook as a labor of love and as a tribute to his father's memory, to gather up the broken threads of the "Guide," to finish collecting material, and weave all into the orderly system the father had outlined. Few can form any estimate of the amount of work which thus devolved upon the son. During its progress he suffered a double bereavement, his loving mother and devoted wife, who had aided him much in his work, both passing over to the "silent majority." How well he accomplished his self-imposed task, the volume of 426 pages, just issued during the past year, speaks for itself. Geologists cannot appreciate too highly the labor and self-sacrifice of the son, in thus carrrying forward to successful completion, under so many discouraging circumstances, a work involving so much toil for one whose daily occupation was foreign to subjects connected with geology.

MEGALONYX IN HOLMES COUNTY, OHIO, 1890.

By E. W. Claypole, Akron, O.

II.

V. *Geographical Range.*

The range of these extinct sloths is, generally speaking, nearly the same for all the genera. Confined entirely to the New World they were, for the most part, inhabitants of South America, but

some of them also occupied the southern portion of North America. Megatherium and Mylodon were two of these, while Skelidotherium of all species was so far as we know confined to South America and Megalonyx to North America and the island of Cuba. At the same time it would be erroneous to infer that the same species were found in both parts of the New World, for this apparently was not the case.

Two or three less known forms have been described—*Nothrotherium*, from Brazil; *Gnathopsis*, of Leidy, from South America, and *Ereptodon*, of the same author, from Mississippi. Only a detached bone or tooth of each of these genera is yet known.

Hitherto, the remains of Megalonyx have not been found farther north than Big Bone Lick, in Kentucky, about twenty miles southwest of Cincinnati and in latitude 38½°. Greenbrier county, West Virginia lies in latitude 38°. At least, this is the case west of the Alleghanies. Possibly, some of the cited instances on the Atlantic seaboard may be a little farther north. But the discovery of this skeleton near Millersburg extends the area over which the animal roamed to latitude 40°, or nearly 120 miles farther north than was before known. Much beyond this limit it is not probable that it will ever be carried, as from what we know of the climate of that era, it is unlikely that it would be sufficiently congenial to allow of its subsistence, especially in the winter.

VI. *Environment and Date.*

Regarding the actual conditions of the region where the skeleton was found and at the time when it lived, it is possible to deduce a few inferences from the facts observed. The swamp lies almost at the extreme edge of the terminal moraine doubtless of the second glacial era, though the southern limit of this apparently here coincides with that of the earlier glaciation. About seven miles to the northeast of Millersburg is a very heavy drift composing for a short distance two lines of moraine between which lies the swamp containing the bones. There is evidence that this was formerly one of those glacial lakes with which the front of the ice-sheet abounded. Indeed it was covered with water except in summer within the recollection of men still living. The peat which has accumulated is in some places ten or eleven feet thick, and beneath it is the shell-marl usually found in these lake-beds.

This graduates downwards into a silt or quicksand without shells, very clammy and of great depth, resembling what is usually deposited from glacial waters. I was informed by Mr. Drushell that some years ago a boring was carried down into this silt to the depth of one hundred and forty feet without reaching the rock. Judging from the topography this is not unlikely. The surface of the drift is here nearly two hundred feet above Millersburg, and its depth is evidently very great. The swamp is on the site of a deep hollow between two lines of morainic mountains on its north and south sides. The outlet is at the east end and is narrow. It has also been cut down a few feet artificially and had previously been somewhat lowered by the outflowing stream. The swamp is very irregular in shape but may measure a mile in length from east to west and half as much in breadth from north to south. In one place a long point projects from its northern bank nearly cutting it into two parts, and opposite this is a small island of the same gravelly material still further separating it. At this point formerly existed a large beaver-dam from which hundreds of gnawed sticks were taken in the digging of the ditch*. This must have aided in holding back the water at least in the western part of the swamp. The outlet leads into a small stream called Doudy's run, and then into the Killbuck and Muskingum.

VII. *The History.*

The sequence of events in the history must have been nearly as follows. The southern line of moraine was formed when the ice-front stood at the south side of the swamp and was nearly at its greatest extension. It consists for the most part of material rolled and washed along under the ice, that is of rounded gravel and clay. A time of recession followed during which little morainic matter was deposited, and the hollow in which the swamp now lies was produced. Another period of rest or of slight advance ensued, and the northern moraine was dropped, meeting the older one at both ends and enclosing between them a rudely crescentic basin. This basin was kept full of water by the melting ice, and its overflow escaped by the lowest point in the rim,

*Some of the tooth-marks which I saw on these sticks are so large that they strongly suggest the great extinct beaver of Ohio (*Castoroides ohioensis*) as the architect of the dam rather than the much smaller living beaver (*C. canadensis*).

which was at the southeastern end. Thus the lake was kept full of "glacier-milk" and the deposit of this excessively fine silt gradually filled it nearly to the level of the overflow. This was a comparatively rapid process as it always is at the present day when glacier streams are ponded back. The absence of shells from all except the uppermost part of this deposit clearly indicates that the basin was filled with the glacial mud before the ice had retreated far to the northward. Life is not usually found in inland and fresh waters when they are kept near or at the freezing-point throughout the year.

Later in the history after the icy water had ceased to enter the basin various fresh water mollusks took possession of the ground, and the uppermost layer is charged with their shells. A cursory examination was sufficient to recognize the following:

Valvata tricarinata,	Planorbis parvus,
Amnicola limosa,	Sphærium sulcatum,
Amnicola porata?	Pisidium virginicum.

Above this layer of shell-marl lies the peat, the product of fresh-water plants which probably took possession of the ground as early as the mollusks. The species are, so far as examined, the same as those now growing in this and other swamps in the state. The thickness of the accumulated mass varies much in different places. In some it has not been penetrated.

From the position in which the bones were found it is evident that the cold period had passed away (as indeed must from other facts have been the case) before the Megalonyx came upon the scene. The filling of the lake with glacial deposit was ended, and the sticky, soft shell-marl was forming at the bottom. A tangled growth of rushes, sedges, and other water-plants occupied its shores and shallows and rendered them soft and treacherous. The bones lay off the projecting cape above mentioned, the hind-quarters being farthest from land. The supposition seems probable, therefore, that the creature was traveling northward, probably making a short summer migration, for it could scarcely live in Ohio in the winter, and undertook to swim across the lake from the island to the point spoken of already, and on attempting to gain the dry land became fastened in the clammy bottom and entangled in the mud and rank vegetation so that it was unable to extricate itself. Struggling would only increase its difficulty, and

in spite of its enormous strength it sank below water and was drowned. Decaying and perhaps in part devoured by other animals its bones fell asunder and were scattered over the bottom of the lake as they have now been found. On this view others probably remain to be recovered, as they may lie at some distance from the spot first struck. So large a bone as the pelvis can scarcely have perished when the clavicle and claws remain perfect. The skull also should be found, and the lower jaw which is one of the most enduring of the bones and is frequently preserved when no other part of the skeleton remains.

VII. *Its date.*

In regard to the date that should be assigned to the creature it is evident that it is post glacial, and as we are unable to assign to the end of the ice-age in this state an antiquity of more than about 10,000 years this puts an upper limit on the age of the fossil. Yet farther, as the cold had entirely passed away and the climate had become almost or quite as to-day, this date must be much farther reduced. And this reduction may be very considerable. We have no reason to doubt that the Megalonyx came into the region as soon as the climate was suitable both for itself and its vegetable food. And that it survived into the human period we have no reason to doubt. Though there is yet no evidence of man and Megalonyx in combination, yet there is reason for believing in the contemporaneity of man and other huge Mammalia in North America. Moreover, the occurrence of one specimen in Tennessee yet retaining fragments of cartilage and tendon attached to its bones is another proof that the species lingered or survived till quite recent times. Whether the specimen in Holmes Co. then belongs to an ancient or a recent animal it is not possible to say, and all that can be determined is that its age probably lies between two and eight thousand years.

PETROGRAPHICAL DIFFERENTIATION OF CERTAIN DYKES OF THE RAINY LAKE REGION.

BY ANDREW C. LAWSON, with analyses by F. T. SHUTT, M. A., F. C. I.

Communication No. 2.

At the Toronto meeting of the A. A. A. S. the writers submitted a paper in abstract bearing the above title. The material for the full paper was not at the time of the meeting complete,

and various vicissitudes have since then interfered with the work. However, as some of the facts observed are of interest it is proposed to give them here without attempting to elaborate them so fully as was originally contemplated.

The dykes of the Rainy Lake region show in a marked degree that variation from a fine texture at the dyke walls to a coarse texture in the middle of the dyke, which is more or less characteristic of dykes the world over. In the abstract referred to it was stated that "On examination of the dykes in question, it became apparent that this variation in the physical appearance of the dykes is not simply one of *texture* or degree of coarseness of the constituent minerals, but it is rather the incidental concomitant of important *structural*, *mineralogical* and *chemical* variations which appear very constantly in the same way in different dykes." It will be the object of the present paper to establish this general statement by giving some account of the facts upon which it is based.

A dyke about 150 feet wide which traverses Stop island on the south side of Rainy lake, in which the variations alluded to are strongly accentuated, will be first described somewhat in detail. From this dyke a series of four specimens was taken, viz.:

I at the contact with the dyke wall.

II at four feet from the contact.

III at fifteen feet from the contact.

IV at seventy-five feet from the contact (middle of dyke).

Textural variation.—To the unaided eye there is apparent a very distinct gradation in texture from that of an aphanitic rock at the contact to that of a coarse gabbro or diorite in the middle of the dyke. The gradation is rapid in the first four feet, less so from four feet to fifteen, and scarcely perceptible from fifteen feet to the middle of the dyke; the rock on which the observations were made in the field presenting a continuous, clean, fresh, glaciated surface. In order to arrive at some definite information regarding the gradation in texture, careful measurements were made of the constituent minerals in thin sections of the different specimens. The following are the results of these measurements:

I Ground mass.	
Pyroxene—largest grains	.0315 mm
Ave. diameter	.030 mm
Feldspar in slender needles.	
Ave. size	.004 × .052 mm

	Magnetite, ave. diameter..........................	.0147	mm
	Porphyritic crystals.		
	Pyroxene, largest polysomatic grain..	1.120	mm
	Feldspar, largest lath-shaped crystal.......	.056 × .560	mm
II	Pyroxene, approx. ave. diameter.................	.840	mm
	Feldspar, " " size...............	.560 × .056	mm
	Magnetite, " . " diameter................	.126	mm
III	Pyroxene in polysomatic masses, ave. diameter....	2.000	mm
	Feldspar, lath-shaped crystals, largest....	.350 × .100	mm
	Magnetite, few scattered grains, ave. diam.......	.700	mm
	Quartz, ave. diameter...........................	.056	mm
IV	Pyroxene, much altered to hornblende, larger gr..	1.000	mm
	Feldspar, ave. size of larger grains...............	2.000	mm
	Magnetite, few large grains, diam...............	.700	mm
	Quartz, larger grains............................	.840	mm

Structural variation.—The specimen taken at the contact with the dyke walls (I) appears in section as a porphyrite. The ground mass is a fine ophitic felt work of plagioclase and greenish yellow pyroxene, with viridite thickly studded with granules of magnetite, all of the latter belonging probably to the final consolidation of the magma. The porphyritic constituents are in the order of their generation (1) Plagioclase in lath-shaped crystals,

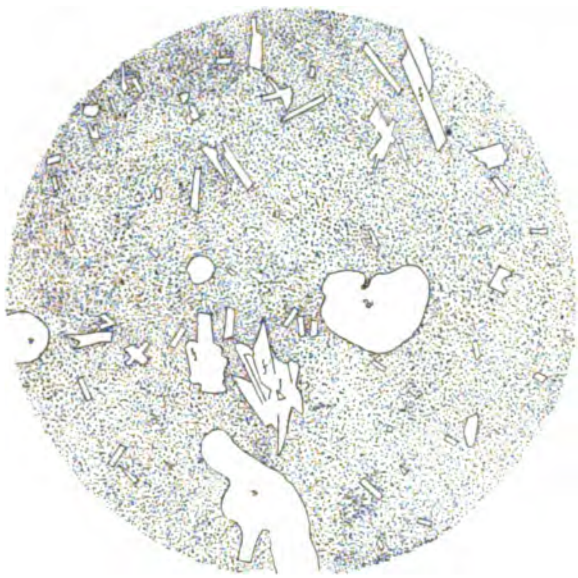

FIG. 1.

Stop Island dyke.—Section of dyke-rock at contact with dyke wall. ×38. a. polysomatic augite; f. plagioclase. Illustrating porphyrite structure.

either in distinctly isolated individuals or aggregated together in irregularly radiating clusters; (2) Augite, in rounded or bleb-like, colorless polysomatic masses. The plagioclase is occasionally included in the augite. The microscopic aspect of this portion of the dyke is shown in fig. 1.

In the specimen taken only four feet from the last, *i. e.*, four feet from the dyke wall, the structure of the rock presents a marked contrast to that just described. There is no ground mass, and the section presents the character of a typical ophitic diabase as shown in fig. 2.

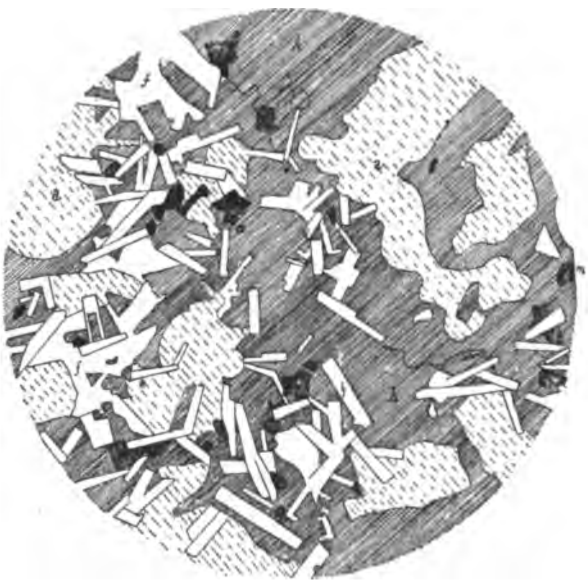

FIG. 2.

Stop Island dyke.—Section of dyke-rock four feet from dyke wall. ×38. a. Augite; f. plagioclase; h. hornblende; m. magnetite. Illustrating ophitic or diabase structure.

In this portion of the dyke the dominant minerals are polysomatic augite and green hornblende. The latter mineral is in part derived from the augite, while part of it presents no evidence of such derivation and may be original. These two minerals occur in large interlocking masses in which are embedded beautifully sharp idiomorphic crystals of plagioclase and irregular grains of magnetite. It seems probable from a careful inspection of the

relative attitude of the constituents that a portion of the augite is of earlier generation than the rest, and earlier than such portion of the hornblende as may be original. The rounded contours of the fresher masses of polysomatic augite suggest analogy with the rounded porphyritic masses shown in fig. 1. In addition to the idiomorphic plagioclase there is a subordinate proportion of plagioclase which shows no crystallographic boundaries. Occasionally a small grain of quartz may be detected. At fifteen feet from the dyke walls the structure is still ophitic. Augite is the dominant mineral and appears to be of two generations, (1) large, irregularly bounded polysomatic masses and idiomorphic crystals, (2) allotriomorphic, interstitial between the idiomorphic plagioclase. Quartz is sparingly present, and magnetite is in large, irregularly scattered grains, some of it allotriomorphically developed about the idiomorphic augite.

In the middle of the dyke the structure is entirely different from either that of a porphyrite or of an ophitic diabase. It is the type of structure characteristic of granite, gabbro, or diorite. All the important constituent minerals interfere with one another, and the only idiomorphic crystals are those of accessory minerals such as apatite. The aspect of a section of this part of the dyke is shown in the drawing, fig. 3. Quartz is abundant, and the augite appears to be entirely replaced by hornblende, so that the rock would be classed with the quartz-gabbros or quartz-diorites according as the hornblende is secondary or original. Considered simply as a hand specimen it is best termed, probably, a uralitic quartz-gabbro.

Mineralogical variation.—The most important mineralogical variation observable in the series of specimens taken across the dyke is the passage from a quartzless rock at the dyke wall to a quartzose one in the middle of the dyke. No quartz can be detected at the side of the dyke. At four feet from the side quartz may be observed in occasional grains, forming an exceedingly small proportion of the constituents; at fifteen feet it is somewhat more abundant, and in the middle of the dyke quartz is a prominent constituent of the rock. Another important change in the mineralogical composition of the rock is the encroachment of hornblende upon the augite as one passes from the dyke walls, and the final complete replacement of the augite in the middle of

the dyke. This change, even though it be due in great part to paramorphism, testifies to an important variation in the character of the rock developed from the same magma at various distances from the dyke walls. The augite nearer the middle of the dyke would appear to be much more susceptible of paramorphic change than that near the dyke walls. The middle part of the dyke is also richer in accessory minerals such as apatite, biotite, epidote, and leucoxene than the lateral parts.

Chemical variation.—The chemical variations observed in this dyke will be gathered from a consideration of the following table of analyses of the specimens above referred to :

Stop Island dyke.

	I.	II.	III.	IV.
SiO_2	47.83	47.08	47.84	57.50
Fe_2O_3+FeO	4.57		6.72	5.07
Al_2O_3	30.28		25.40	23.44
CaO	6.72		8.44	5.62
MgO	4.32		5.25	2.76
K_2O	trace		.60	.45
Na_2O	1.30		2.55	2.01
P_2O_5	2.19		.94	2.02
Loss on ig.	2.05		2.53	2.25
	99.26		100.27	101.12
Sp. g.	3.028	3.060	3.080	2.856

These analyses show a remarkable increase in the proportion of silica in the middle of the dyke over that in the lateral parts. The difference in silica content of about 10 per cent is sufficient to separate the specimens into two distinct rock species according to current methods of classification. The difference is in keeping with the quartzose character of the middle of the dyke as compared with the quartzless character at the side, and also harmonizes with the difference in specific gravities given in the table.

Thus in half the space of a sharply defined dyke only 150 feet wide our study reveals variations in all of those characters which we make use of in the description and classification of rocks. Totally distinct types of texture, structure and composition belong to the same geological unit-mass. This fact suggests an interesting commentary upon our system of rock classification. Is such classification in cases like the present, or even generally, anything

more than a classification of hand specimens? Of what philosophic or geological value is a classification of specimens into different species and types when they may all be one and the same rock crystallized from the same magma within a few feet of one another. The geologist who knows his rocks in the field as well as in the laboratory finds such classifications very little expressive of geological truth. But the differentiation in character of this dyke rock suggests other matters than a criticism of classification, namely, a consideration of the conditions under which such differentiation was developed from a common magma. From the nature of the case we are able to form fairly satisfactory conceptions as to two conditions which are commonly regarded as having a para-

FIG. 3.

Stop Island dyke.—Section of dyke-rock seventy-five feet from dyke wall (middle of dyke). .×38. f. plagioclase; h. hornblende; q. quartz; m. magnetite. Illustrating allotriomorphic-granular or granitic structure.

mount influence upon the solidification of rock from magma. These are (1) the relative pressure, and (2) the relative rate of cooling under which the different parts of the magma solidified. The magma being confined between parallel sharply-cut fissure walls may fairly be assumed to have been under the same constant hydrostatic pressure in any given horizontal plane during the

time of its solidification. It may also be fairly assumed that those portions of the magma adjacent to the fissure walls cooled more rapidly and solidified earlier than did the middle portion. Thus although we have in current petrographical literature numerous references to great pressure as one of the chief causes of the development of the coarser texture and granitic structure of the plutonic rocks as compared with that manifested by rocks which solidify at or near the surface, the present case seems to establish the fact that both types of rock structure may be developed under one and the same pressure. Difference in pressure under which magmas solidify is, therefore, probably, not so important a cause of the difference in structure and texture of rocks as is generally supposed. On the other hand we have in the case under consideration strong presumptive evidence that the rate of cooling which must have been rapid at the sides and slow in the middle, exercised the controlling influence over the character of the rock developed from the magma in any given part. With regard to the conditions which determined the chemical and mineralogical differentiation of the dyke rock very little can be definitely affirmed. It seems probable, however, that the explanation lies in the earlier separation of the more basic minerals accompanied by a transference of more acid residues (or solvents) to the middle portions, which transference was facilitated by the gradual solidification of the magma from the dyke walls toward the middle, and by the movement of the water constituent of the magma towards the middle. The water of the magma, so long as the latter remained liquid, would have a tendency to escape to the surface. This tendency, taken with the tendency of the higher portions of the dyke to solidify more rapidly than the deeper-seated portions would create a current obliquely through the magma, upward and inward from both sides. This current would aid in the transference from the sides to the middle of the more acid portions of the magma from which the more basic had separated out.

Numerous other dykes have been examined with the same general result as that arrived at by a study of Stop Island dyke. In none of these, however, was the differentiation in character found to be quite so strongly accentuated as in the Stop Island dyke. A series of specimens taken across the dyke which cuts the southeast shore of White-fish bay, and which is referred to in former

notes as the White-fish Bay dyke, was analyzed with the following results :

White-fish Bay dyke.

	I	II	III	IV
SiO_2	47.50		48.08	52.47
Fe_2O_3+FeO	7.40		9.07	6.31
Al_2O_3	22.44		23.67	25.54
CaO	10.21		10.99	6.62
Mg O	3.71		3.92	2.31
K_2O	1.29		.49	.54
Na_2O	1.62		1.92	3.23
P_2O_5	.34		1.11	1.16
Loss on ig	2.85		.83	1.28
	97.36		100.08	99.46
Sp. g.	2.927	3.081	3.030	2.870

I near contact with dyke wall.

II six feet from contact.

III thirty feet from contact.

IV sixty feet from contact (middle of dyke).

In this dyke the gradation in texture is as pronounced as in the Stop Island dyke but the differentiation of structure is not so marked. In I the ground mass has the character of a fine-grained ophitic diabase and the porphyritic constituents present no great contrast in size to those of later generation which have crystallized around them ; and in IV the ophitic structure is not entirely replaced by the granular. This dyke is noteworthy for the abundance of hypersthene which is present near the dyke walls. This hypersthene is a porphyritic constituent, and has well defined crystallographic form. It has not been observed in specimens from other portions of the dyke and its occurrence recalls the similar occurrence of enstatite in the Jack-fish Lake dyke and in the Rat-root Bay dyke which has been noted in a former paper. There is as in the Stop Island dyke a regular increase in the proportion of quartz in passing from the dyke walls to the middle and in the latter part of the dyke the augite is entirely replaced by hornblende. The analyses of this dyke rock and of the Stop Island dyke rock show throughout an unusually high percentage of alumina.

A dyke sixty-five feet wide cutting biotite gneiss with a northwest strike on the north shore of Shoe Bay, Rainy Lake,

afforded three specimens taken in the same sequence as before. The first, from the contact, shows a pronounced porphyrite structure consisting of a fine ground mass of plagioclase, augite and magnetite in which are imbedded lath-shaped crystals of rather cloudy plagioclase of an earlier generation and polysomatic aggregates of pyroxene, which in many cases is partially altered to a serpentinous, greenish-yellow substance either on the periphery, having a fresh core, or in patches and shreds through the section. In the second specimen, taken at six feet from the contact, the structure is ophitic and in marked contrast to that of the last. The plagioclase is fresh, the augite is in scattered grains and in polysomatic aggregates and is more or less altered to hornblende. Quartz is present and is intergrown with the feldspar after the manner of pegmatite. Magnetite occurs in skeletal forms and apatite in slender needles. In the specimens taken from the middle of the dyke the general structure is granular rather than ophitic although the latter structure is observable. Augite is seen in occasional large polysomatic grains with a good deal of filmy or shreddy perimorphic hornblende and some chlorite. Hornblende also occurs in independent masses. Quartz is very abundant and is nearly all intergrown with feldspar in pegmatitic structure. Magnetite and apatite are present, the former in irregular scattered grains and the latter in slender needles. A partial chemical examination of the specimens from this dyke gave the following figures for the percentage of silica and the specific gravity:

	Contact.	Middle.
SiO_2	49.26	51.04
Sp. g.	3.077	3.007

Near the mouth of Shoe Bay, on the north side is another dyke similar to the last. It is about seventy feet wide. Thin sections of three specimens taken from the same parts of the dyke as before, present the same general features as in the dyke last described. The rock at the contact is a porphyrite with the usual plagioclase crystals and augite aggregates imbedded in a fine-grained base. The latter is remarkable for the uniformly even distribution of the magnetite grains. The porphyritic augite has no crystallographic boundaries and its alteration is for the most

part marginal. No quartz was observed. At six feet the structure is again ophitic. Quartz is present. Magnetite is in large sized, sparsely scattered grains. A little pyrite also occurs. The structure of the middle part of the dyke is for the most part granular but with some idiomorphic plagioclase. The augite is generally fresh, but has associated with it hornblende and chlorite as alteration products. Quartz is abundant with uniform orientation over wide, and in the section isolated, areas. The following are the figures for the silica percentage and specific gravity of the three specimens:

	Contact.	Six feet from contact.	Middle.
SiO_2	48.65	47.92	49.28
Sp. g.	3.088	3.079	3.016

Similar specimens were taken from a dyke on Risky Island, Rainy Lake, which is nearly in a line with the Stop Island dyke and the Shoe Bay dyke last described. The contact rock is as before distinctly a porphyrite similar to that represented in fig. I. The minerals are all fresh. Plagioclase in large crystals and augite in single and in polysomatic grains, are imbedded in the usual fine ground mass, which in this, and in all the dykes described, is apparently holocrystalline and micro-ophitic. At six feet from the dyke wall the structure is ophitic but with some allotriomorphic plagioclase. The augite is mostly replaced by hornblende. Quartz is plentiful in pegmatitic development. Magnetite or titanic iron is abundant but without any trace of leucoxene. In the middle of the dyke the ophitic structure is still observable but most of the constituent minerals are allotriomorphic. The augite is very largely replaced by hornblende. Quartz is observed to present the same ophitic relations to the idiomorphic plagioclase as does the augite, and it contains inclusions of apatite and microlites. Leucoxene with cleavage traces of titanic iron is abundant and in large grains. The following are the figures for the percentage of silica and specific gravity of these specimens:

	Contact.	Six feet from contact.	Middle.
SiO_2	49.77	49.64	52.31
Sp. g.	3.100	3.044	3.016

On the south side of Rainy river opposite Sec. 20, Tp. 5 S., R. XXVIII of the Canadian township survey, a dyke was observed having a width of from 150 to 200 feet and cutting hornblende schists with a north-northwest strike. No specimen was here obtained at the immediate contact, and in one a little removed from the contact the porphyritic structure was only represented by blebs of polysomatic augite imbedded in an ophitic base which approached in texture that of the specimens taken at four or six feet from the contact in other dykes. The ophitic structure prevailed in two other specimens, one taken at six feet from the contact and one from the middle. Quartz was observed in both of these but not in the first. The percentage of silica and specific gravity of the first and third specimens is as follows:

	Near Contact.	Middle.
SiO_2	49.82	50.10
Sp. g.	3.221	3.068

Series of specimens from several other dykes were also examined, but the limit of space will not permit of further detailed descriptions. Generally, however, it may be said that the porphyrite structure almost invariably characterizes the dyke rock at the contact and that this rapidly grades into an ophitic structure which in turn appears to grade very gradually into the granular structure. The latter, it must be said, is developed to the entire exclusion of the ophitic structure only in a few of the cases observed. The increasing proportion of quartz toward the middle of the dykes is a very constant character. In one dyke, namely that on the south side of Rainy river opposite the town of Fort Frances, well defined crystals of enstatite were observed in the rock at the contact as a porphyritic constituent while none of this mineral was observed in other parts of the dyke.

NOTES ON THE GEOLOGY OF SOUTHWESTERN NEW YORK.

By Gilbert D. Harris.

During the early part of the present season, a well was sunk at Jamestown, N. Y., to a depth of 3263 feet. For the proprietors, the undertaking was somewhat unfortunate, since neither oil nor

gas—the objects sought—were met with in paying quantities. To the geologist, however, the extensive suit of drillings, carefully preserved and labelled, are of uncommon interest owing to the depth and peculiar location of the well; it furnishes him data for determining the lithological characters, thickness, and amount of dip in this region of the several formations penetrated,—items heretofore but vaguely known from surface observations.

I. *Jamestown Well Section.*

CHEMUNG GROUP.

(A). The Conglomerate.—"Bed rock," according to the well record,* was encountered at a depth of 220 feet below the surface†. The sample from this point consists of very finely pulverized milky quartz, derived without doubt from a large, hard boulder. One foot below, a typical upper Devonian conglomerate appears. This at first is composed most exclusively of quartz pebbles, ranging in size from a pea downwards. In color, they are white, rose, or yellowish; in form, angular or sub-spherical. Presently a fine-grained sandstone makes its appearance, forming a matrix, as it were, for the coarse quartz pebbles. This is of a light, bluish-gray color, is slightly micaceous and argillaceous, and at a depth of 240 feet, constitutes about 60 per cent. of the rock material. Seventeen feet lower still, few pebbles appear. The total thickness of the conglomerate is therefore not less than 36 feet.

By referring to plate IV, it will be seen that the upper surface of this formation is 1105 feet A. T., or, as shown in the foot-note below, about 660 feet stratigraphically below the Panama conglomerate.‡

*Kept by Mr. W. R. Reynolds of Jamestown, N. Y., through whose kindness the writer was enabled to examine the samples.

†The mouth of the well has been estimated to be 4 feet above the R. R. station, i. e. 1325 feet A. T. See Bulletin No. 5, U. S. Geological Survey, p. 211.

‡This result is obtained in the following manner: (The altitudes A. T. are mainly from Carll's Rept. IIII. 1883, 2d Geol. Surv. Penna.)

Altitude, Pope Hollow congl. (up. sur.) at P. H...1940 feet A. T. (p. 181)
" " " " at McCoy's
6 miles south-southwest of Pope Hollow.........1800 feet A. T. (p. 206)

Difference...............................140 feet.

Hence, rate of dip along this line =23+feet per mile. Produce this line 4 miles to "A" (see Pl. III). Here the horizon of the Pope Hollow congl. should have an elevation of 2032+ft. A. T. This less 190 feet

The discovery of a bed of this character, occupying so low a position in the Chemung group, may at first seem somewhat strange; nevertheless similar beds occupying similar positions have been met with before. Professor Hall, in discussing the "Carboniferous System" of this part of the state, remarks: "There is another conglomerate in Chautauqua county, and in some places in Alleghany county, which was briefly noticed under the Chemung group. This, however, is a thin mass, and wherever it has been found in place, is associated with fine-grained compact sandstones, and frequently contains the fossils of the Chemung group. In the northern part of Chautauqua county, I found some loose masses of this conglomerate, containing fossils known to belong to the Chemung group, and by this they were chiefly identified. The aspect of the rock is also somewhat different; the pebbles smaller, more round, and not of the same white quartz which occurs in the higher rock."*

The writer also has seen a like formation as far north as the village of Cherry Creek, with an altitude above tide of not over 1400 feet.

It would indeed be premature to assert that all these exposures are but the northern outcroppings of the low-lying Jamestown conglomerate; no assertion of the kind, either pro or con, can be made with propriety until the localities so vaguely referred to by Hall are more definitely known.†

In endeavoring to trace this formation southward and ascertain its relations to the oil sands of Pennsylvania, one meets with two serious difficulties: (1) the number of borings is, for some distance, comparatively limited, and (2) the records, if kept at all, are generally too inaccurate to be of any particular value. One

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(see Pl: v) = elevation of the Panama cong. at "A." Alt. Panama conglomerate at Panama, 1671 feet A. T. (p. 181), hence, difference in alt. at "A" and Panama = 171 feet.

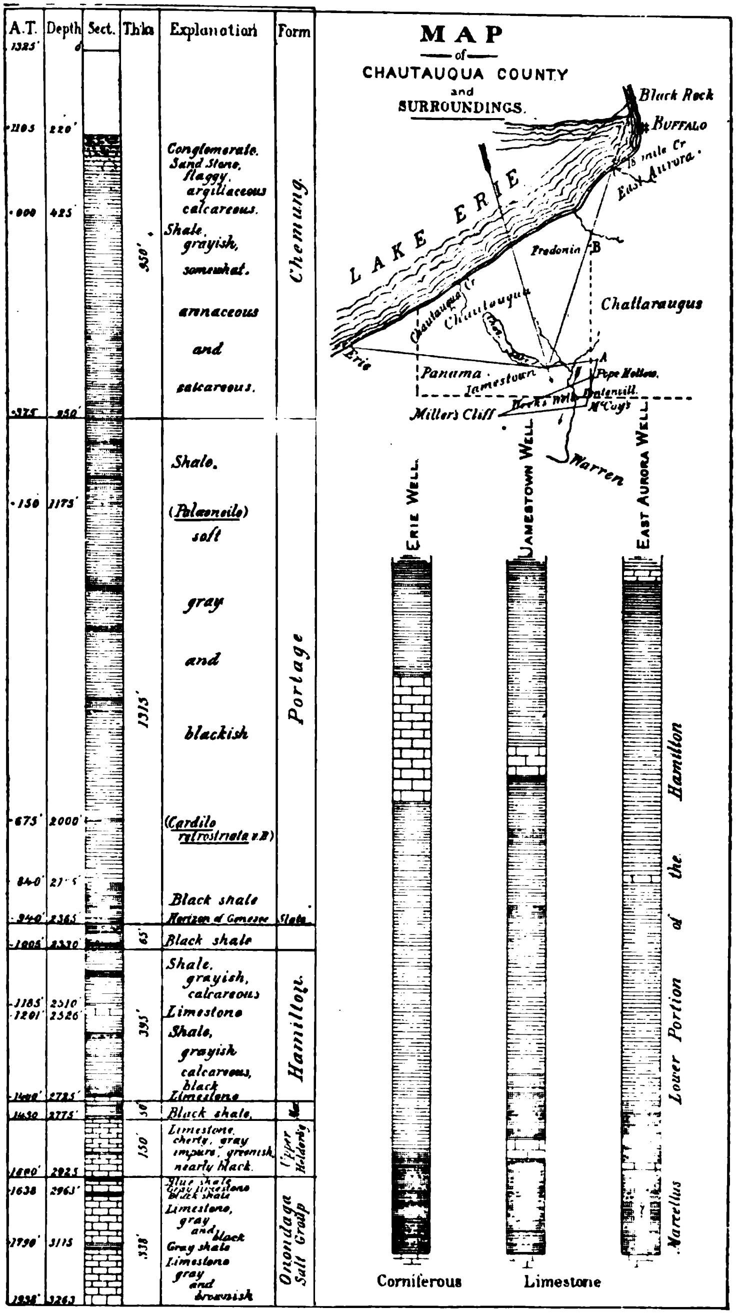
$171 \times \frac{13}{23}$ (Jamestown being $\frac{13}{23}$ the distance from Panama to "A") = 96. ∴ 1671 ft. + 96 ft. = alt. Panama congl. at the Jamestown well if it were there represented . . 1767 feet A. T.

Alt. Jamestown well conglomerate (see Pl. III.) . . . . 1105 feet A. T.

Difference . . . . 662 ft. Q. E. D.

*Geology of N. Y., Part IV. 1843, foot-note, p. 286.

†Prof. J. P. Lesley has too hastily correlated the beds mentioned by Hall, with "one of the thin conglomerates outcropping at Warren, Pa." 2d Geol. Surv. Pa. I, 1874, p. 108.


A.T.
Depth
Sect.
Thkn
Explanation
Form
Conglomerate.
Sand Stone,
flaggy,
argillaceous
calcareous.
Shale,
grayish,
somewhat.
arenaceous
and
calcareous.
Chemung.
350'
Shale.
(Palaeoneilo)
soft
gray
and
blackish
(Cardita retrostriata v.B.)
Black shale
Horizon of Genesee
Portage
1315'
Slate
Black shale
65'
Shale,
grayish,
calcareous
Limestone
Shale,
grayish
calcareous,
black
Limestone
Hamilton.
395'
Black shale.
50'
Limestone.
cherty, gray
impure, greenish,
nearly black.
Upper Helderberg
150'
Blue shale
Gray limestone
Black shale
Limestone,
gray
and black
Gray shale
Limestone
gray
and
brownish
Onondaga Salt Group
338'
MAP
of
CHAUTAUQUA COUNTY
and
SURROUNDINGS.
LAKE ERIE
Black Rock
BUFFALO
18 mile Cr
East Aurora
Fredonia
B
Chattaraugus
Chautauqua Cr
Chautauqua
Erie
Panama
Jamestown
A
Pope Hollow
Dalenvill
M'Coys
Miller's Cliff
Warren
ERIE WELL.
JAMESTOWN WELL
EAST AURORA WELL
Lower Portion of the Hamilton
Marcellus
Corniferous
Limestone

well, only, seems to deserve special notice here; it is located about 8½ miles southeast of Jamestown, and is commonly known as the Weeks or Fentonville well. In this, Carll finds the upper surface of the second sand of the Warren oil field at a depth of 276 feet below the surface, or 964 feet A. T.* It evidently forms here a conglomerate, for it is said to consist of blue sandstone "mixed with white pebbles;" its thickness is given as 30 feet. This corresponds fairly well with the Jamestown conglomerate, in lithological characters, in thickness, and certainly in stratigraphic position.†

(B). Sub-Conglomerate Beds.—Immediately beneath the conglomerate, follow gray arenaceous shales, containing but little calcareous matter, with few or no traces of animal life. These grade down into softer and more argillaceous deposits, which in turn at a depth of 385 feet, suddenly become hard and calcareous,‡ and so continue for at least 35 feet. Still lower, the soft argillaceous phase reappears, and throughout the remainder of the Chemung group, continues with but slight variations.

PORTAGE GROUP.

The dividing line between the Portage and Chemung groups in this section, has, to be sure, been somewhat arbitrarily placed at a depth of 950 feet. Yet, that this represents the truth with a fair degree of approximation may be judged from the following considerations: (1). Bits of calcareous matter, apparently of shells, were found in the drillings from a depth of 900 feet. Since the fauna of the upper Portage is exceedingly meager, the bed here represented is doubtless Chemung. (2). The material at a depth

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*Rept. IIII, 2d Geol. Surv. Pa. 1883, p. 17.

†By taking into consideration the elevations of the Pope Hollow conglomerate (or its probable equivalent—the Wrightsville conglomerate) as it outcrops at Miller's cliff (1620 ft.), McCoy's (1800 ft.) and Pope Hollow (1940 ft.), as given by Carll in Rept. IIII, and by obtaining from any reliable map the distances between these three points, its average dip will, upon computation, prove to be 23—feet per mile, S. 18° or 19° W.

Assuming that this is the approximate direction and amount of dip of the conglomerate in the Jamestown well, its upper surface should be found in the Weeks well at a depth of *984 feet A. T.*, since the latter is 8.4 miles S. 32° E. of the former. This apparent discrepancy can be readily accounted for, since, as will be shown farther on, the dip becomes greater, and swings gradually to the east as we descend in the geological scale. (See "Stratigraphical Deductions.")

‡Probably the representative of the "hard shell" in the Fentonville well. See 2d Geol. Surv. Pa. IIII, p. 17.

of 950 feet is somewhat arenaceous and micaceous, and contains fragments of coal as does the Portage in northern Chautauqua. (3). Below, the arenaceousness disappears; and at a depth of 1175 feet, a small *Palæoneilo* was found, which is certainly a Portage form.

Assuming that the group in question begins at a depth of 950 feet, it may be thus characterized: An argillaceous formation throughout; generally steel gray in color, though interspersed above with occasional dark, thin, bituminous strata which become thicker towards the base of the group. In two instances, viz., at depths of 1450 and 1725 feet, these dark shales assume a reddish or brownish hue, and represent, doubtless, similar conditions of deposition if not similar horizons to those termed "red rock" in the Fentonville well.

A very perfect specimen of *Cardiola retrostriata* von Buch. (*Glyptocardia speciosa* Hall) was found at a depth of 2000 feet.

At the base of the Portage group as represented in this section, there is a mass of slaty shale 100 feet thick. No representative of the Cashaqua shale seems here to exist, at least none such was recognized.

GENESSEE SHALE.

Gas was encountered at a depth of 2265 feet in far greater quantities than at any other place in the well. The shales at this point appear fissile, and give a brown streak as does the typical "Genessee slate." Below, however, they become slaty and appear like the black beds in the Portage above.

HAMILTON GROUP.

There is much doubt in the mind of the writer as to where the Genesee terminates and the Hamilton begins. As remarked above, the lower portion of the black shale deposit is by no means typical Genessee; neither can it be classified as Hamilton.* Beds of this group, however, do appear at a depth of 2330 feet, and continue with slight variations for 180 feet; they are gray, soft, and calcareous, and contain numerous fragments of shells.

At a depth of 2510 feet, a hard limestone makes its appearance; black at first, but grayish below, and more or less cherty

*It may be that there is here a partial transition from the New York system of classification to that of Ohio, wherein the black shales (2165 ft.–2330 ft.) represent in part the Huron group of that state.

throughout. Its stratigraphic relation to a similar though thicker bed encountered in a deep well near Erie, Pa., is shown on plate IV.*

Below this limestone, gray calcareous shales reappear, and continue to a depth of 2670 feet, when they suddenly become very dark and fissile. This phase continues for about 45 feet when a second limestone appears. Nothing corresponding to this was noted in the Erie well; but it apparently does have a representative in a well† at East Aurora, Erie Co., N. Y., as shown in the plate just referred to.

MARCELLUS GROUP.

At a depth of 2725 feet, black shales reappear and continue for about 50 feet, to the upper surface of the Corniferous limestone. It is possible that all these shales do not belong to the Marcellus group, but that they are in part Hamilton. Again, the 45 foot bed of dark shale immediately overlying the limestone just described, appears in every respect like a typical Marcellus deposit.

UPPER HELDERBURG GROUP.

The Corniferous limestone was found at a depth of 2775 feet. It seems to present no unusual features, being generally pure though sometimes siliceous, and varying in color from a light to a dark shade of gray. No line of demarcation is observable by which this limestone can be separated from the Onondaga below. Their total thickness is about 150 feet.

ONONDAGA SALT GROUP.

This differs from the above, principally by the more frequent occurrence of argillaceous bands, and the greater diversity in texture and color of the limestone strata. The group was penetrated to the depth of only 338 feet.

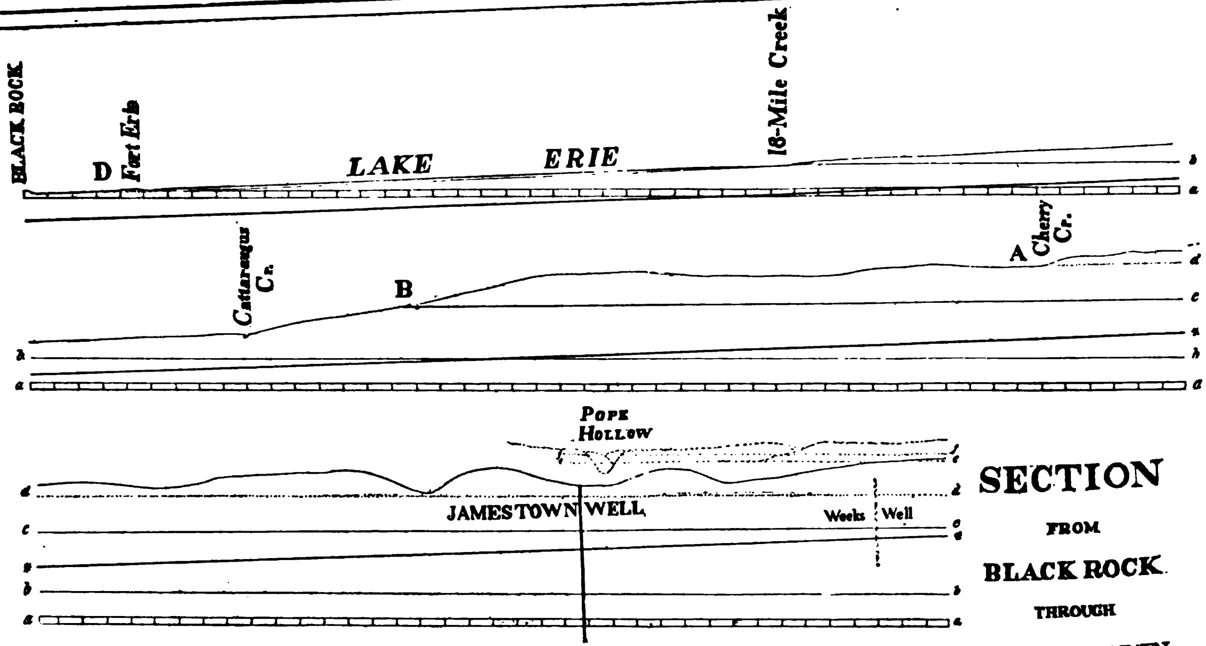
II. Stratigraphic Deductions.

(A) Dip.—From the following localities and altitudes of the Corniferous limestone (upper surface), the amount and direction of its dip can be readily ascertained.

Black Rock, Erie Co., N. Y.	+625 ft. A. T.
Jamestown, N. Y., 59.3 mls. S. 18° 10′ W. of Black Rk	−1450 ft. A. T.
Erie, Pa., 80 mls. S. 49° 30′ W. of Black Rock......	−730 ft. A. T.

*Compiled from manuscript notes kindly furnished by Mr. Charles S. Prosser. U. S. Geological Survey.

†Also from Mr. Prosser's notes.



SECTION FROM BLACK ROCK THROUGH JAMESTOWN TO THE PENA LINE

—, Sea-Level; a—a, Corniferous Ls; b—b Genesee Slate (Upper surface); c - c, Base of Chemung; d d, 1st Warren Oil-Sand; e e, Horizon of Upper Surface of Panama Conglomerate; f—f, Horizon Pope Hollow Congl (Upper Surface.)

Scale of Miles

Vertical Scale, 1/10 in. - 100 Ft.

Whence, having solved with respect to dip,—

Dip of Corniferous limestone=43 feet per mile, south, 17° E. Likewise by taking the localities and altitudes of the Pope Hollow conglomerate as given in the preceding pages, its dip will be found to be 23-feet per mile, south 18° or 19° west.

The difference in direction and amount of dip in these two formations is, accordingly, very marked; yet it can be readily explained: While the effects of the Cincinnati uplift are so felt in this region as to give the dip of the Corniferous limestone a moderate eastern deflection from true meridian, the thickening towards the south and the thinning towards the west of the superincumbent formations is such as to render the dip in the Pope Hollow conglomerate far less than that of the Corniferous limestone, and to give it a strong western deflection.*

That these formations thin out rapidly going westward, is a fact too well known to require any special comment here; the "thickening towards the south," can be demonstrated as follows:

Altitude of horizon "C" at "B" (See plate v.) about....	1150 ft. A. T.
" " " Jamestown well...........	375 ft. A. T.
Difference in altitude..........	775 ft.
Distance between "B" and Jamestown...............	27½ mls.
.·. Rate of dip along this line........................	28+ft. per ml.
Dip of Pope Hollow conglomerate in same direction..	23 ft. per ml.

Hence the thickening of that portion of the Chemung group which lies beneath the Pope Hollow conglomerate, at a rate of 5 ft. per mile.

Again, Alt. of horizon "b" at "C".....................	573 ft. A. T.
" " " Jamestown well.........	-940 ft. A. T.
Difference in altitude...........................	1513 ft.
Distance from "C" to Jamestown....................	44 miles.

Hence, rate of dip of lower surface of Portage group=34.4 ft, per mile, or about 6.4 ft. more than that of the upper surface.

Finally, Alt. of Corniferous limestone at Black Rock....	625 ft. A. T.†
" " " " Jamestown....	-1450 ft. A. T.
Difference in altitude...........................	2075 ft.
Distance between Black Rock and Jamestown........	59.3 mls.

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*A similar difference in rate of dip of the Corniferous limestone and upper Chemung, or lower Coal Measures, has been noted by Prof. H. S. Williams along his Genesee section. Bull. U. S. Geol. Surv., No. 41, pp. 103-104.

†C. A. Ashburner: "Petroleum and Natural Gas in the state of New York." Trans. Amer. Ins. Min. Eng., Vol. xvi, 1888, p. 921.

Hence, rate of dip of lower surface of Marcellus group = 35 – ft. per mile, or, slightly more than that of the upper surface of the Genesee slate.

It should be borne in mind that the "dips" given above are but general averages along a line from Black Rock to Jamestown, or about S. 18° 10′ W., and do not, therefore, represent the true rates of dip in the various formations referred to. This fact, however, has no particular bearing on the results just obtained; but there is another consideration that must be taken into account here, and that is local dip.

In the Colburn well at Fredonia, the Corniferous limestone was found at a depth of 315 feet* below tide; in the Jamestown well, as has already been remarked, the same formation was met with at a depth of 2775 feet below the surface, or 1450 feet below tide; the distance between the two localities being 24 miles, it necessarily follows that the average rate of dip of the Corniferous limestone is here no less than 47 feet per mile. This is greater by 4 feet per mile than the average dip given for the area, Black Rock—Jamestown—Erie, evidencing, accordingly, a local rise in this limestone formation in the vicinity of Fredonia. This would probably slightly modify the general inclinations of the various formations given on plate IIII, and would tend to lessen the rate of dip from Black Rock to a point in the section not far from "B," and to cause an increase from the same point to Jamestown.

(B). Thickness.—With the above-given data, it now becomes possible to determine the total thickness of the Marcellus, Hamilton, and Genesee, as well as that of the Portage, with greater precision than has been done heretofore. Making a slight allowance for the influence of the Fredonia rise, the dip from "D" (the point at which the upper surface of the Corniferous limestone descends to the level of lake Erie) to "C" (where the base of the Portage dips beneath the lake) is about 32 feet per mile. Since the distance is 15 miles, the total thickness of the Marcellus, Hamilton, and Genesee, is 15 × 32 ft. or 480 ft.

Again, the dip along line "b"–"b," from "C" to "B" is about 31½ ft. per mile. The distance between these two points is 16 miles; "B," moreover, is about 577† feet above "C." The thick-

*Ibidem.

†Determined by the writer while under the auspices of the Palæozoic Division of the U. S. Geological Survey.

ness of the Portage group at "B," is therefore $31\frac{1}{2}$ ft. $\times 16 + 577. = 1081$ ft., or, approximately, 1080 feet.

Hence, contrasting these figures with those derived from the Jamestown well section we have:

	Erie, or Northern Chautauqua county.		Jamestown well.
(1)	1080 feet	Portage	1315 feet.
(2)	480 feet	Genesee Hamilton Marcellus	510 feet.

Professor Hall has estimated the "aggregate thickness" of the Portage group in northern Chautauqua county as "little less than 1400 feet."* This result he evidently obtained by supposing that the dip along the shore of lake Erie from near the mouth of Eighteen Mile creek to Chautauqua creek is 25 feet per mile. Calculations based upon the depths already given at which the Corniferous limestone was struck in the Fredonia and Eric wells, together with its altitude at Black Rock, show conclusively that the true rate is but 16 feet per mile. Making this change, the "aggregate thickness" becomes 1040 feet,—a fairly accurate result.

The Genesee slate is said by Hall to be 23 feet and 7 inches thick† as it crops out on the shore of lake Erie, near the mouth of Eighteen Mile creek. Add to this, 300 feet, for the combined thicknesses of the Hamilton and Marcellus as given by professor Williams in "The Petroleum Age,"‡ and the total for the three groups becomes 323 feet and 7 inches; or, about 150 feet less than the estimate given above (see "2").‖

III. Addenda.

POPE HOLLOW SECTION.

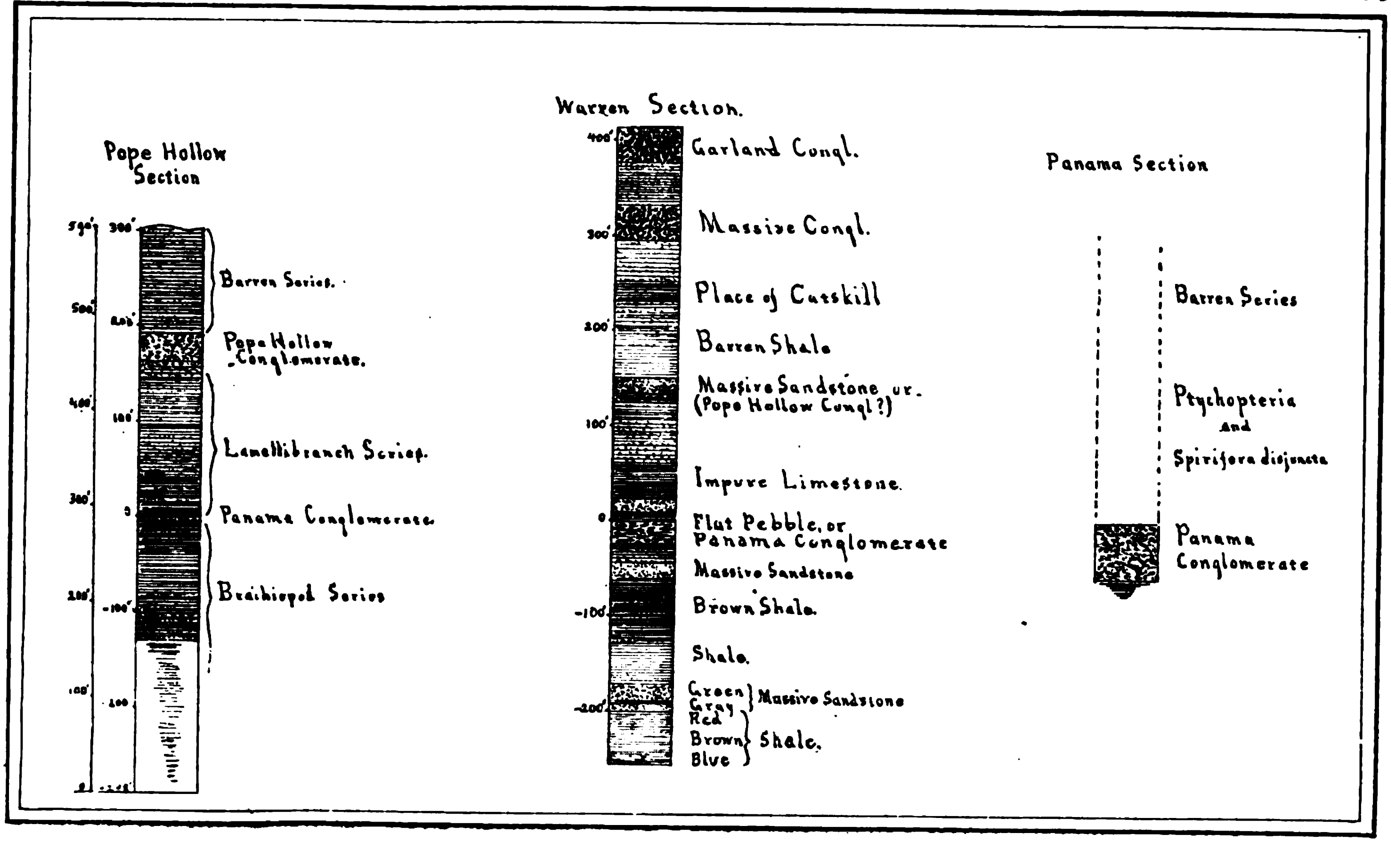
In order to further the correlation of the conglomerate and inter-conglomerate beds in southern Chautauqua county, N. Y., with those of Warren county, Pa., the writer takes this opportunity to make known the following details regarding a section

*Geology of New York. Part IV. 1843, pp. 238–239.

†Geol. N. Y. Pt. IV, 1843, p. 221.

‡Op. cit. vol. VI, June, 1887, p. 1642.

‖According to the MS. notes of Mr. Prosser, the aggregate thickness of these groups in the East Aurora well section, amounts to 520 feet at least. This is not surprising, since according to Hall, both Genesee and Hamilton thicken rapidly going eastward from lake Erie.


Pope Hollow Section
Barren Series.
Pope Hollow Conglomerate.
Lamellibranch Series.
Panama Conglomerate.
Brachiopod Series
Warren Section.
Garland Congl.
Massive Congl.
Place of Catskill
Barren Shale
Massive Sandstone or (Pope Hollow Congl?)
Impure Limestone.
Flat Pebble, or Panama Conglomerate
Massive Sandstone
Brown Shale.
Shale.
Green Gray } Massive Sandstone
Red Brown Blue } Shale.
Panama Section
Barren Series
Ptychopteria and Spirifera disjuncta
Panama Conglomerate

fact that it contains few or no organic remains. It is apparently homogeneous throughout, consisting of thin, hard, evenly bedded flaggy layers which are very noticeably micaceous.

From the so-called barren shales of the Warren section Prof. Hall cites *Tropidocaris interrupta* and "fragments of the shells of *Spirifera disjuncta*," while the corresponding beds in the Panama section are "totally barren of fossils of any kind—as far as observed."

U. S. Geological Survey, December, 1890.

THE ROCKS AT ST. PAUL, INDIANA, AND VICINITY.

CHARLES S. BEACHLER, Crawfordsville, Ind.

The rocks at St. Paul, Indiana, exposed along the small stream known as Flat Rock, may be described as an arm two or three miles wide, extending in length for about fifteen miles, in a southwesterly direction from the main belt of Upper Silurian rocks.

This arm may readily be referred, by its fossils, to the Niagara group; its exposure being a result of the eroding away of the thin Upper Helderberg stratum of limestone overlying it, while the streams have cut their channels through the rocks, thus giving a section of the entire strata of the Niagara group in this state.

The rocks are covered with Devonian dirt which has been carried a short distance from the north-east, as seen by the glacial markings on the underlying rocks; the fossils found in the dirt, *Favosites forbesi* Hall, *Atrypa reticularis* Linn., are in a perfect state of preservation and show no marks of their transportation—so they could not have been carried very far.

A section of the rocks at St. Paul may be taken as a typical section of the rocks of this group in this state, as it exhibits four *well marked strata* as follows;

Drift, Devonian dirt, containing Devonian corals and brachiopods.

No. 5. Upper Helderberg limestone overlying Niagara.

No. 4. Blue shale (The Waldron fossil beds, 10 feet). Seen on Mill creek, a short distance above the point where it flows into Flat Rock.

No. 3. Thinly laminated limestone, thickness 15 feet; containing *Pisocrinus gemmiformis* S. A. Miller; *P. globosus* Ringueberg;

"pear shape crinoid;"* *Stephanocrinus osgoodensis* S. A. Miller.

No. 2. Cherty beds, containing thin plates of limestone in which are found the same fossils as in No 3., thickness 15 feet.

No 1. Heavy laminated quarry rock, containing fossils in No. 3 but not in such profusion, the upper or "flagging" layers containing in addition cystids and large cephalopods, *Gyroceras elrodi* White, *Orthoceras annulatum* Sowerby.

Comparing the outcrops of Decatur county—Greensburg, Harris City, Westport—with the quarries at Osgood in Ripley county, they may be readily referred to bed No. 1 at St. Paul.

At Moscow, in Rush county, below the village, is seen two feet of shale (Waldron beds) overlain by Upper Helderberg; half a mile below are quarries of limestone, equivalent of bed No. 1 at St. Paul, in which were found new genera of crinoids.

At Anderson, in Madison county, the rocks are more of a magnesian character, containing *Pisocrinus pentalobus* W. & Sp., *P. gemmiformis* S. A. Miller, *P. globosus* Ringueberg, equivalent of bed No. 1 at St. Paul.

Comparing the fossils we find them nearer the New York than any other western locality; the majority of species are identical, with twice the number of species of crinoids, the new forms being of the same genera, while not a single *Caryocrinus* which occurs in New York, Illinois, Wisconsin, Iowa, and is abundant in Tennessee, has been found in Indiana; a few large cystids however have been found, mostly in the limestone.

The true crinoids in the limestone are so small that very little can be told of their structure as they are only partially weathered out.

FURTHER NOTES ON THE CHEYENNE SANDSTONE AND NEOCOMIAN SHALES.

BY F. W. CRAGIN, Topeka, Kansas.

During the summer of 1890, and since my article, "On the Cheyenne Sandstone and the Neocomian Shales of Kansas," as it appeared in the AMERICAN GEOLOGIST, was written, I have gathered some additional data touching these formations.

By the favor of Mr. Frank D. Healey, I have been shown a lo-

*An undescribed crinoid, with no arms or arm openings, no rhombs or pores, probably a transition between crinoids and cystids.

cality on the North Canadian or Beaver river, about longitude 100° 12′ W., where both the larger and the smaller varieties of *Gryphæa pitcheri* occur in Loup Fork Tertiary conglomerate, some of the specimens showing very little wear, and bearing witness to the former extension of the Neocomian over that region.

Occurrences reported to me from points not far northeast of Tascosa, Texas, are probably referable to the Neocomian.

I have also reconnoitred that portion of the "Cherokee Outlet" and "Panhandle of Texas" adjacent to the Cimarron river and the Panhandle extension of the Santa Fe railway southwest to the main Canadian. Loup Fork Tertiary sandstone, or more commonly the sandy decomposition-product of the same, cloaks the divides and their south slopes, resting in general directly upon "red-beds" of almost vermilion red color and of supposed Triassic age above, and of dull, brownish red color and supposed Permian age below, the great gypsum horizon of that region; yet the data in hand leave little room to doubt that lower Neocomian strata once prevailed from the western border of McPherson county, Kansas, across Ford and Kingman counties and portions of the Cherokee Outlet and the Public Lands, to the foundations of the Llano Estacado.

By the courtesy of Prof. Hill, of the Texas geological survey, I have been able to traverse with him a course from Millsap, Texas, to Weatherford, and thence to Granbury, and thus to confirm his reference in 1889,* of Nos. 5 and 6 of my Belvidere section to his Fredericksburg shale and Trinity sandstone, respectively.

The palæontologic and lithologic identity of No. 5 of my Belvidere section with a certain, shell-conglomerate occurring at Weatherford—the lowest known Gryphæa-bearing horizon of Texas—is such as to warrant me in asserting the essential chronologic equivalency of the two horizons.† This conclusion is borne out by the general resemblance of the fauna of the strata a little above the Weatherford conglomerate to that of those similarly situated with reference to Belvidere No. 5, though in these there is not quite so close a lithologic correspondence.

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*Annual Report of the Geological Survey of Arkansas for 1888, p. 115.

†Among other forms common to both strata, *Idonearca vulgaris*, not hitherto listed from Texas, was incidentally noticed.

I would here call attention to the small phase of *Gryphæa pitcheri* which abounds alike in the Weatherford shell-conglomerate and in horizon No. 5, of the Belvidere section, and which I have elsewhere characterized as a *pitcheri-like* form tending more or less toward the aspect of *G. incurva*. It might quite as appropriately be described as a form of *Gryphæa incurva*, tending more or less toward *G. pitcheri*. From the view that it is merely the young of *G. pitcheri*, there are strong reasons for dissenting; for if it were, it would seem a strange circumstance that *G. pitcheri* should present to us only *young* in its lowest horizon in both Texas and Kansas, and chiefly adults in its higher horizons, associated with occasional small forms much more like said adults than like the small phase under discussion. I hold it to be a strongly marked type, an ancestral, or perhaps a physico-geographic form of *G. pitcheri*, of at least varietal value and of great importance as a key to stratigraphic relationships, and I would propose for it the name of *Gryphæa pitcheri* Mort., var. *hilli*.

The Cheyenne sandstone may be regarded as the much abbreviated representative of the series of incoherent sandstones underlying the above-mentioned Weatherford shell-conglomerate, and outcropping between Millsap and Weatherford in alternation with harder strata containing *Pleurocera*, *Nerinæa* , and other forms to the most of which southern Kansas can show nothing similar. The upper and major portion of the basal stratum of friable ferruginous-yellow and white sandstone seen on Grindstone creek and its tributaries a little east of Millsap, resting upon the eroded Carboniferous—from the harder elements of which its basal conglomerate portion is derived,—bears especial lithologic resemblance to a very common phase of the Cheyenne sandstone.

BAUXITE IN ARKANSAS.

By John C. Branner, Ph. D., State Geologist of Arkansas.

The geological survey of Arkansas has discovered deposits of bauxite in that state, the first considerable ones thus far found in this country. In 1887 a small deposit was discovered in Floyd county, Georgia, but that is said to cover "an area of about half an acre" only.*

*Trans. Am. Inst. M. E., XVI., p. 905.

The Arkansas beds occur near the railway in the vicinity of Little Rock, Pulaski county, and near Benton, Saline county. The exposures vary in size from an acre to twenty acres or more, and aggregate something over a square mile. This does not, in all probability, include the total area covered by bauxite in the counties mentioned, for the method of occurrence of the deposits leads to the supposition that there are others as yet undiscovered by the survey.

In thickness the beds vary from a few feet to over 40 feet, with the total thickness undetermined; the average thickness is at least 15 feet.

These Arkansas deposits occur only in Tertiary areas and in the neighborhood of eruptive syenites ("granites") to which they seem to be genetically related. In elevation they occur only at and below 300 feet above tide level, and most of them lie between 260 and 270 feet above tide. They have soft Tertiary beds both above and below them at a few places and must therefore be of Tertiary age. As a rule, however, they have no covering, the overlying beds having been removed by erosion and are high enough above the drainage of the country to be readily quarried. Erosive action has removed a part of the bauxite in some cases, but there are, in all probability, many places at which it has not yet been even uncovered.

It is pisolitic in structure, and, like all bauxite, varies more or less in color and in chemical composition. At a few places it is so charged with iron that attempts have been made to mine it for iron ore. Some of the samples from these pits assay over 50 per cent. of metallic iron. This ferruginous kind is exceptional, however. From the dark red varieties it grades through the browns and yellow to pearl gray, cream-colored and milky white, the pinks, browns and grays being the more abundant. Some of the white varieties have the chemical composition of kaolin, while the red, brown and gray have but little silica and iron, and a high percentage of alumina. The analyses given below show that this bauxite is as good as that of France, Austria, and Ireland, for the manufacture of chemical products, for refractory material and for the manufacture of aluminum by the Deville process. Should there be a market in this country for such material Arkansas will be able to supply any demand that may be made for

it. No use has ever been made of the Arkansas material except for road building; indeed it was not known what it was until January last when the announcement was made by the state geologist in a letter to the governor.

The following analyses made by the state geological survey show the composition of average samples:

PARTIAL ANALYSES OF BAUXITE FROM ARKANSAS.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Alumina	55.59	57.62	58.60	55.89	44.81	62.05	55.64	51.90
Silica	10.13	11.48	3.34	5.11	33.94	2.00	10.38	16.76
Ferric oxide	6.08	1.83	9.11	19.45	1.37	1.66	1.95	3.16
Titanic oxide					2.00	3.50	3.50	3.50
Loss on ignition (water)	28.99	28.63	28.63	17.39	17.28	30.31	27.62	24.86

Average of fourteen partial analyses of bauxite from France, Austria and Ireland.*

Alumina	52.7	per cent.
Silica	7.1	" "
Ferric oxide	19.1	" "
Water	16.4	" "

THE BEACH PHENOMENA AT QUACO, N. B.

By Charles Livy Whittle, Cambridge, Mass.

The abnormally high tides of the bay of Fundy have permitted the existence of a beach line, or bar across the harbor of Quaco, a parallel of which does not occur at any point on the Atlantic coast south of the seaward end of the bay. Similar bars now connect the former islands of Marblehead and Nahant off the coast o Massachusetts. These, like bars in general, have their concavity opening towards the fetch of the waves, and at no time are they submerged unless it be during the progress of a severe storm which may temporarily destroy them, wholly or in part, by beaching. They are usually capped by a ridge of large-sized pebbles forming the storm beach.

The harbor of the village of Quaco, which is an arm of the bay of Fundy, in extent is some three miles north and south, and two miles deep. This beautiful water area is bordered by steep cliffs

*From analyses principally by Saint-Claire Deville given in the Ann. de Chimie et de Physique, LXI, 1861, p. 309 et seq.; Bull. Soc. Geol. de France, XVI, 1888, p. 345; Dingler's Polytechnisches Journal, 198, p. 156, and 234, p. 465; Bischof's Feuerfesten Thone, p. 194; Percy's Metallurgy, p. 133.

on the north and south cut in red Triassic sandstone, and stretching across it in magnificent sweeping curves are two walled beaches marked by lines of shingle; an outer one, or bar, only broken in two places by small streams which cross it at low tide; an upper one, or normal storm beach, also broken in two places but at high as well as low tide. A coastwise stream flowing south during the retreat of the tide and north during its advance has produced the outer beach aided by the configuration of the coast line at this point. In all respects, but two, it is in nowise dissimilar to ordinary bars formed southward along the Massachusetts coast. These two differences are dependent on the abnormal run of the tides in the bay. Here the bar forms an outer water line at low tide; off Massachusetts such a bar marks a water line at high tide only. The Quaco bar is covered by the advancing and retreating tides twice a day; the Massachusetts bars are seldom or never covered. To the rapid run of the tides in the bay the existence of the bar is due, as the energy of the breakers seems to spend itself against the beaches mainly at high and low tides, and points intermediate between these feel but little of the force of the waves as expressed on the two lines of shingle. The tides come up the harbor faster than a man can walk, pass over the bar without destroying it and as rapidly advance to the upper beach line, completely submerging the lower. Conversely the same is true of the retreating tide. In cross section the lower beach is very variable not only in its several parts but there are variations dependent upon the season. Old residents of Quaco informed me that they had known it to be nearly destroyed during severe storms from the south-east. Landward, in hight above the gently-sloping surface of the beach, as a whole it is seldom over five feet and locally decreases in elevation so that it practically disappears. The seaward slope is much steeper and the bar appears much more pronounced viewed from this side. At the two ends the ridges of shingle come together outlining a rude moon-shaped area. Between these two lines it is difficult to find large pebbles such as make the crest of the inner or outer beach lines. From this it seems probable that the outer zone of shingle was either brought there from the north or south and not transported seaward by the undertow from the upper beach.

In color, the sand forming the bottom of the harbor, which has

been derived from the Triassic sandstone, is the usual red that characterizes that formation, only perhaps it is a little more brilliant than the color of the Connecticut Triassic. The broad, gently-inclined beach taken as a whole and seen through the blue-green waters of the bay coupled with the steep cliffs that appear purple in the distance, and which in many places present mural faces three hundred feet high, is wonderfully beautiful.

In genesis the phenomena shown along the upper or present main beach line depend on several geological processes. The geology of the area immediately about the harbor, although relatively simple, is extremely interesting. At the south end a rugged promontory, called Quaco Head, some eighty feet in hight, projects into the bay for a distance of nearly a mile. This on the south-east side is made up of Carboniferous rock (which carries the manganese ore-bodies of the province) dipping gently nearly due south. The lowest member revealed is a much-altered melaphyre, probably extensive, on which lies a fine-grained, agglomeritic limestone carrying masses of melaphyre at its base, varying in diameter from mere pebbles up to boulders several feet across. Scattered through it and a calcareous shale next above, occur manganese ores as veins traversing the strata at random and concretionary masses occupying a definite zone. On the north side of the head are thin-bedded sandstones and shales of Triassic age dipping gently north-west and lying unconformably upon the Carboniferous—the line of contact between the two, being beautifully exposed in a cliff a little distance down the coast south of the head. Here the Triassic carries numerous pebbles derived from a small bed occurring in the Carboniferous, approximately a foot in thickness.

The red sandstone, following the coast northward through the village of West Quaco, passes into a typical beach conglomerate lying in the same position as farther south, and forming cliffs against which the present waves break at high tide. Induration of the conglomerate is but slightly advanced as the pebbles are easily separated from one another with the hands. The mutual interpenetration of sand grains observed in much indurated quartzites, however is well illustrated here. All the pebbles show perfect impressions of these pebbles juxtaposed. The impressions are best developed upon the flat surfaces, indicating that gravity was

mainly the operative force producing them. Macroscopically the outlines of the pebbles do not indicate distortion or crushing; only occasional cracks radiating from the indentations tell us how yielding has taken place. Nearly all of them have been derived from the Carboniferous limestone and they therefore show a great uniformity as to size and outline, being well water-worn and quite broad in proportion to their thickness,—the longer axis corresponding to the bedding, although in the hand specimens the rock appears entirely homogeneous approximating a fine-grained marble. The present upper beach is made up of these pebbles simply removed from the Triassic beach conglomerate with but little evidence of attrition and orginally derived from a Carboniferous limestone; so that at present there is a Quaternary conglomerate being laid down, the pebbles of which were eroded during Triassic time. That the pebbles are not being extensively water-worn by the present wave action is shown by the fact that the indentations are only partially worn away. This probably is due to the readiness with which they are supplied from the relatively incoherent conglomerate, their abundance over-taxing the power of the waves to reduce them so that they can be carried out to sea by the undertow, and permitting them to be built rapidly into a conglomerate.

Along the line of the present upper beach there are numerous sea-caves. One of these deserves especial mention as it has given rise to a remarkable mushroom-shaped pillar, locally known as the "Devil's Pulpit." This pillar, which is some eighty feet in hight, stands at the north end of Quaco Head and has been carved out of melaphyre by the wearing away of the Triassic sandstone immediately to the west, lying unconformably on the melaphyre leaving a wall of homogeneous rock projecting to the north. The waves advancing from the east first formed a sea-cave at this point and finally perforated the mass leaving it attached to the main body only on the landward side and at the bottom.

Extending westerly from the extremity of Quaco Head inland for a distance of about one mile and at an elevation of eighty feet above the present high tide level there occurs as fine an example of an elevated sea beach as occurs anywhere along our Atlantic coast above high water mark. It is a perfect post glacial beach, having a gentle ascent comparable to that of the main beach in the harbor. Its shore line is very pronounced and is carved in

rocks of varying character, mainly those that are exposed along the south-east side of the head, eruptions, limestones and calcareous red shale, the last two carrying manganese ores principally as nodules of psilomelane and wad. A line of more or less distinctly marked sea-caves and cliffs and their accompanying taluses extends across the head forming the water line. Since the close of the glacial period the northward extension of the beach has been nearly carried away by the encroaching waves, and in Quaco harbor a fine section is exposed. Going seaward from the shore line a progressive diminution in the size of the detrital material and its gentle easterly dip are noticeable, the outermost portion being largely clay grading westerly into coarser layers; and, finally, at the shore line occurs normal coarse beach conglomerate the material of which although waterworn shows the transientness of the sea at this level by its much greater augularity compared with the material composing present beach deposits. All the strata exposed carry an appreciable percentage of nodules of manganese ore derived from the calcareous red shale and limestone; the wad which these rocks contain being incoherent was transported farther seaward, and the general dark color of the clays is probably attributable to this cause. Nearly a square mile of beach remains in and west of the head. No permanent streams traverse it, and it remains to-day essentially in the same condition as when the sea retreated. The advent of the ocean apparently found no large glacial boulders to contend against; along the coast line none are now seen and the smooth surface of the beach is unbroken except by an occasional outcrop of limestone or melaphyre. That the beach remains in so perfect a condition to-day points to a comparatively rapid retreat of the sea; while the occurrence of the sea-caves, imperfect though they may be, and the line of cliffs along the margin of the sea point as strongly to a degree of permanency in the relation of the land to the sea for a considerable length of time that would hardly be expected if the current theory as to the cause of elevation and submergence of the land during glacial time be adhered to.

Cambridge, Mass., Jan. 26th, 1891.

HISTORY OF LAKE AGASSIZ.

By WARREN UPHAM, Somerville, Mass.

From Part E. of the annual report of the Geol. and Nat. Hist. Sur., Canada, 1888-89.

I.

During the recession of the ice-sheets of both the earlier and later epochs of glaciation, drainage from the ice-border in many places flowed in channels from which the streams became turned by the slopes of the land into more northern courses when this was permitted by the farther retreat of the ice. Where the slope is southward, free drainage from the melting ice took place along the present valleys, and these were partially filled with modified drift, remnants of which form terraces and plains on each side of the present streams. But on areas that sloped more or less directly toward the receding ice-border, the streams of that time eroded channels which were abandoned when lower outlets were uncovered. Because of the large supply of water from the glacial melting, some of these river-courses became conspicuous topographic features, as noted by Dawson* McConnell,† and Tyrrell‡ in various parts of the region between lake Agassiz and the Rocky mountains. On a slope nearly parallel with the retiring ice-border, the deserted river-courses were seldom the outlets of lakes of considerable size; but where a large area was inclined toward the ice-sheet, it was covered by an expanse of fresh water, formed by the streams that flowed down from the melting ice surface and overflowing across what is now a line of water-shed between great drainage basins, until the continued recession of the ice allowed the lake to be discharged by the natural slope of the land. Lake Agassiz was the largest of these glacial lakes. Others existed in the basins of the James, Souris, and Saskatchewan rivers, of which the two last named outflowed eastward into lake Agassiz. The basins of the great Laurentian lakes, which are being studied by Mr. G. K. Gilbert of the United States geological survey, were also filled at this time to higher levels than now, determined by the elevations of the outlets through which they then flowed south-

* Report on the Geology and Resources of the region in the vicinity of the Forty-ninth Parallel, pp. 263-265: Geological Survey of Canada, Report of Progress for 1882-83-84, p. 150 C.

† Geological Survey of Canada, Annual Report, vol. i, for 1885, pp. 21 and 74 C.

‡ Do., Annual Report, vol. ii, for 1886, pp. 43, 45 E, and 145, 146 E.

ward to the Mississippi and finally eastward to the Mohawk and Hudson.*

In tracing the history of lake Agassiz it will be needful to review the recession of the ice-sheet which was its northern barrier, as the stages of that recession are shown by the successive terminal moraines of Iowa, Minnesota, South and North Dakota, and Manitoba; to observe the stages of the lake itself which are recorded in its successive beaches; and to note the contemporaneous history of the glacial lakes on the west, whose outflow by the Sheyenne, Pembina, and Assiniboine brought large deltas into the western edge of lake Agassiz and spread deposits of fine silt over extensive areas of its bottom.

When the latest North American ice-sheet attained its greatest area, its southern portion from lake Erie to North Dakota consisted of vast lobes, one of which reached from central and western Minnesota south to central Iowa. This Minnesota lobe in its maximum extent ended near Des Moines, and its margin was marked by the Altamont moraine, the first and outermost in the series of eleven distinct marginal moraines of this epoch which are recognizable in Minnesota. When the second or Gary moraine was formed, it terminated on the south at Mineral Ridge in Boone county, Iowa. At the time of the third or Antelope moraine, it had farther retreated to Forest City and Pilot Mound in Hancock county, Iowa. The fourth or Kiester moraine was formed when the southern extremity of the ice-lobe had retreated across the south line of Minnesota and halted a few miles from it in Freeborn and Faribault counties. The fifth or Elysian moraine, crossing southern Le Sueur county, Minnesota, marks the next halting-place of the ice. At the time of formation of the fifth moraine, the south end of the ice-lobe had been melted back a hundred and eighty miles from its farthest extent, and its southwest side, which at first rested on the crest of the Coteau des Prairies, had retired thirty to fifty miles to the east side of Big Stone lake and the

* "Changes of level of the Great Lakes," by G. K. Gilbert, in The Forum, vol. v, pp. 417-428, June, 1888. Geol. Sur. of Canada, report of Progress to 1863, pp. 910-915. C. Whittlesey, "On the Fresh-water Glacial Drift of the Northwestern States," 1864, pp. 17-22, in Smithsonian Contributions, vol. xv. J. S. Newberry in Report of the Geological Survey of Ohio, vol. ii, 1874, pp. 50-65, with three maps. "The Lake Age in Ohio," by E. W. Claypole, pp. 42, with four maps, Trans. of the Geol. Soc. of Edinburgh, 1887.

east part of Yellow Medicine county, Minn. During its next stage of retreat this ice-lobe was melted away from the whole of Le Sueur county, and its southeast extremity was withdrawn to Waconia in Carver county, where it again halted, forming its sixth or Waconia moraine. The seventh or Dovre moraine marks a pause in its recession when its southeast end rested on Kandiyohi county. Probably nearly all of the southern half of Minnesota was at this time divested of its ice-mantle, while nearly all of the northern half was still ice-covered. By its next recessions the glacial border was withdrawn to the eighth or Fergus Falls moraine, and the ninth or Leaf Hills moraine. These are merged together in the prominent accumulations of the Leaf Hills, which lie in southern Otter Tail county, Minnesota, reaching in a semicircle from Fergus Falls to the southeast, east, and northeast, a distance of about fifty miles, and marking the southern limits of this ice-lobe when it terminated half-way between the south and north borders of Minnesota.* The south part of lake Agassiz probably began to be uncovered by the retreating ice-sheet between its stages marked by the Waconia and Dovre moraines; and this lake reached northward from lake Traverse 100 to 125 miles along the Red River valley when the Fergus Falls and Leaf Hills moraines were accumulated.

On the west side of lake Agassiz the Dakota lobe of the ice-sheet, from its junction with the Minnesota lobe near the head of the Coteau des Prairies, twenty-five miles west of lake Traverse and Brown's valley, at first reached about 200 miles south along the valley of the James or Dakota river to Yankton and the Missouri; but it was gradually diminished in its extent until, at the times of formation of the Kiester, Elysian, Waconia, and Dovre moraines, it no longer retained its lobate outline. While these moraines were being formed in Minnesota, the southwestern boundary of the ice-sheet in South and North Dakota passed from the vicinity of Big Stone lake and lake Traverse northwesterly along moraine belts that have been traced through Sargent, Ransom, Barnes, and Griggs counties, North Dakota, and by the sources of the James and Sheyenne rivers. During the later stages represented by the Fergus Falls and Leaf Hills moraines, the Dakota

* For detailed descriptions of these moraines, and of the recession of the ice sheet in this state, see Geology of Minnesota, vols. I and II.

ice-front appears to have become again lobate, extending from the west shore of lake Agassiz southward and then westward and northward, between the lake area and the Sheyenne river, to the prominent and typical moraines that are found south of Stump and Devil's lakes, on the Big Butte, about Broken Bone lake and northward, and on Turtle mountain. In their remarkable development these moraines are similar to the massive Leaf Hills, with which they seem to have been contemporaneous.

The course of the ice front where it formed the northern barrier of lake Agassiz, at the time of its accumulation of these great moraines of the Leaf Hills and the south side of Devil's lake, is marked by morainic deposits both east and west of the lake near the latitude of 47° 10′, which passes twenty miles north of Fargo, by an unusual abundance of boulders near this latitude and farther north on portions of the till forming each side of the lacustrine area; and by a tract of till which stretches across the Red River valley at Caledonia, constituting the bed and banks of the river along the Goose rapids. In the lake this morainic till was spread with a generally even surface, but it has many small inequalities, the higher portions being three to five feet or rarely ten feet above adjoining hollows. Boulders and gravel are plentiful on its surface, this being the only interruption of the lacustrine and alluvial clayey silt which elsewhere continuously occupies the central part of this valley plain from near Breckenridge to Winnipeg.

Toward the east the ice-sheet at this time had receded from the southwest part of lake Superior, which was held about 500 feet higher than now and overflowed to the Saint Croix and Mississippi rivers by the way of the Bois Brulé river and Upper Saint Croix lake. It seems nearly certain also that the ice-border continued across Green bay and the north part of lake Michigan; and further east, I think that it probably crossed southwestern Ontario and the central or northern portions of New York, Vermont, New Hampshire, and Maine. The Laurentian lakes were dammed by the retreating glacial barrier and overflowed at the lowest points on their southern water-shed.

During the formation of the tenth or Itasca moraine, crossing the lake region at the head of the Mississippi, the ice-sheet bounding lake Agassiz probably extended thence northward, passing

not far west of Red lake and the Lake of the Woods, to the vicinity of Winnipeg, the Bird's Hill group of osars being perhaps deposited at the angle where this boundary of the ice-sheet turned back southwestward. In that course it seems to have reached across the lake area to the boulder-strewn escarpment of the Pembina mountain east of Thornhill, and beyond to have passed south along the west shore of lake Agassiz into North Dakota, to Pilot Knob in sec. 5, T. 154, R. 56, thence westward to the north side of Devil's lake, and thence north northwestward by the east part of Turtle mountain and along the moraine of the west part of the Tiger hills and of the Brandon and Arrow hills.

The eleventh or Mesabi moraine, well developed in northeastern Minnesota, is probably represented by morainic accumulations north of Pokegama Falls of the Mississippi, about Bowstring lake, the head of the Big Fork of Rainy river, east of the Narrows between the south and north parts of Red lake, and on the east part of the Tiger hills. Lake Agassiz had contemporaneously a length of more than 300 miles, from lake Traverse to near the south end or lake Winnipeg. Later moraines, formed at times of halt or re-advance, interrupting the recession of the ice-sheet between northern Minnesota and Hudson bay, have not been determined; but I believe that they exist and await discovery when the glacial drift of that wooded and very scantily inhabited region shall be fully explored.

The highest of the Herman beaches of lake Agassiz extends in Minnesota, as traced in that survey, to the north side of Maple lake, twenty miles east-southeast of Crookston, and probably it continues thence into the forest region on the east, where it is impracticable to follow its course, to the vicinity of Red lake; and on the west side of lake Agassiz it reaches through North Dakota and at least fourteen miles into Manitoba, terminating on the northern part of the Pembina escarpment somewhere between Thornhill and its northern end, that is, between fourteen and forty miles north of the international boundary. Before the formation of this beach was completed, the ice-sheet had retired from the lake area as far north as the beach extends. During pauses of this glacial recession the Dovre, Fergus Falls, Leaf Hills, and Itasca moraines were formed, showing a northward retreat of the ice-border across a distance of about 150 miles in central Minne-

sota and 150 to 200 miles in North Dakota and southern Manitoba, with a maximum of probably not less than 300 miles in the Red River valley, where lake Agassiz would doubtless cause a more rapid melting of the ice-margin. Through this time the river Warren eroded a channel about fifty feet deep, approximately from 1,100 to 1,050 feet above the sea, or perhaps it eroded only the lower half of that depth, in the moderately undulating sheet of till which reached across the present valley of lakes Traverse and Big Stone. The shortness of the time probably occupied in the formation of the beaches of lake Agassiz may well astonish us in what it implies concerning the rapidity of the recession of the ice-sheet, and the brevity, geologically speaking, of the stages of pause or re-advance when its moraines were accumulated.

The retreat of the ice seems to have uncovered the southwest border of lake Agassiz earlier than its shores farther north and on its east side, as is shown by the Milnor beach, a less distinct shore deposit than the Herman beach and 20 to 25 feet above it, which was observed near Milnor, North Dakota, and along a distance of about ten miles thence northwest to the Sheyenne, but was not recognized farther north nor in Minnesota. The formation of the Sheyenne delta had begun at this time of the Milnor beach, and continued through the time of the Herman beach, with which latter the Buffalo, Sand Hill, Pembina, and Assiniboine deltas were also contemporaneous. The departure of the ice from the Red River valley seems to have been too rapid to permit the accumulation of definite shore deposits on the borders of lake Agassiz, excepting the scanty Milnor beach derived from the Sheyenne delta, until its outlet was cut down to the level of the Herman beach, which probably represents a time of much slower erosion of the outlet, due to diminished glacial melting and smaller volume of the outflowing stream.

Compared with the level of the present time, the highest Herman beach has a gradual ascent from south to north which averages nearly a foot per mile, amounting to about 175 feet in the 224 miles from the mouth of the lake at its southern end to the international boundary. The mouth of the lake was then about 1,055 feet, and its surface on the international boundary about 1,230 feet, above the present sea level. It is further found that

in the northern part of the explored area of lake Agassiz this upper or Herman beach, which is single along the southern part of the lake, becomes divided into numerous parallel beaches that were formed at intervals of pause in a progressive elevation of that area. A portion of these relative changes of level, however, was due to a subsidence of the lake itself toward the north, on account of the diminution of its attraction by gravitation toward the ice-sheet, proportionate with the decrease of the ice in its final melting. As many as six other Herman stages below the highest are recognizable by beach deposits, which indicate a rise of the land combined with a sinking of the lake to the amount successively of about 8, 10, 7, 15, 10, and 5 feet, or in total of 55 feet, on the line between North Dakota and Manitoba, while yet the relative elevations of the lake and the adjoining land along its southern part for some seventy-five miles northward from lake Traverse remained with only slight changes, not sufficient for the formation of any secondary beach ridge.

In a later part of this report the discussion of the causes of these changes in the hight of the land and of the lake is accompanied by a table of the present elevations of the successive beaches formed by the lake on its west side through its entire existence, until it was drained to the levels of lakes Manitoba and Winnipeg. The two highest beaches (*a* and *aa*) in the Herman series of this table were not found north of the Pembina Mountain escarpment; but the next two (*b* and *bb*) are well developed at Brandon and near Neepawa, reaching thus to the northern limit of my exploration at the south end of Riding mountain. During the interval between these Herman beaches *a* and *b*, the combined rise of the land and fall of the lake were only eighteen or twenty feet on the international boundary; but in this time the southern end of the ice-lobe west of the lake had been withdrawn from the east part of the Tiger hills to Riding mountain, and the Assiniboine delta was being rapidly deposited. The northward extent of lake Agassiz in its subsequent Herman stages is not definitely determined, but evidently some of the upper beaches observed by Mr. Tyrrell on the foot slopes east of the escarpments of Riding and Duck mountains belong to this series, the highest, according to information supplied by him, being in lat. 51° 52′ or two hundred miles north of the international boundary, at an elevation of about 1,460 feet above the sea.

EDITORIAL.

IT is our painful duty to announce the death of our beloved brother and colleague, Alexander Winchell, of Ann Arbor, Mich., which took place at his residence at nine o'clock on the morning of February 19, 1891. His fatal malady, which had been insidiously advancing on him for several years, was not known nor recognized in its true character until a short time before his demise. Although diagnosed as "aortic stenosis," its effect, which on post-mortem examination was found to have pervaded nearly his whole body, impairing the necessary circulation of the blood to the great secretory organs, was so general and pronounced, that it became a matter of astonishment that he had survived and labored so long.

He was a man of strong natural physique, of indomitable will, unremitting industry with an insatiable love for work in his profession, of broad philanthropy, of penetrating reason, of fearless pursuit of the truth, at home in any realm of nature's handiwork which he considered permeated with the essence and will of its Creator; a geologist who embraced geology in all its ramifications, ambitious to serve the world by contributing to its fund of advanced knowledge, an enthusiastic teacher, systematic and orderly to the smallest detail, in sentiment sensitive and delicate as a woman, in principle rigid and uncompromising as law itself; a tender-hearted son, father, husband and brother, generous to a fault; a self-made man who, born a poor boy, did not content himself with the condition of his birth, a product of American institutions and opportunities working on one of America's own scions. He was born December 31, 1824. His aged mother survives him.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Cyclosphæroma trilobatum,—A new fossil Isopod from England. Dr. Henry Woodward in the Geological Magazine (December, 1890) gives a most interesting and valuable description of a new isopod from the Great Oolite of Great Houghton House, Northampton. The specimen was found in the white crystalline limestone and is in a fair state of preservation.

CYCLOSPHÆROMA, H. Wood. gen. nov.

General outline nearly circular, almost as broad as it is long. Cephalon rounded and tumid in outline; eyes moderately large, cornea vitreous; thoracic segments seven in number, broader than head-shield or telson, first segment coalesced with cephalon; segments of abdomen coalesced together, but telson apparently distinct. Appendages? (imperfectly preserved.)

C. trilobatum is the species here described and figured. The breadth of this species is 33 mm. and the greatest length 41 mm. Dr. Woodward remarks this as one of the most curious examples of isopods ever seen.

Zittel's Handbuch der Palæontologie. The fourth part of vol. iii of palæozoology has just been received and completes vol. iii. This part contains the Reptilia from the seventh order (Crocodilia) and the Aves, thus bringing the volume up to the final Vertebrata, the Mammalia. The usual completeness of description prevails as has characterized the whole of this magnificent work. We have reason to hope that the final part will contain a most comprehensive index to the several volumes both botanical and zoological thus making the whole work one of inestimable value, or the index might be issued as a separate part and form a volume in itself.

Building Stone in New York. In the Bulletin of the N. Y. State Museum (vol. xii, No. 10) Mr. John C. Smock (economic geologist to the State Museum) describes the geological position and the geographical distribution of the various building stones arranged with reference to their geological characters being first divided into crystalline and fragmental rocks. Then descriptions are given of the principal quarry districts, which are followed by "The use of stones in the cities" which chapter exhibits the great amount and variety of stones used for building in any one city; the work then concludes with chapters on "Physical and Chemical Tests" and "On the Durability of Building Stones and the Causes of Decay." The report is accompanied by a well executed map of the state showing the various quarry districts and the whole forming a most valuable addition to the literature of economic geology.

Sanguinite, a new mineral. In the Mineralogical Magazine (vol. ix,

No. 42, 182) H. A. Miers describes this apparently new mineral which was observed on specimens of argentite from Chanarcillo. To the naked eye this mineral appeared to be göthite, the microscope, however, revealing its true character, which must be referred to another mineral. No quantitative examination was made on account of the small quantity of material; a qualitative analysis, however, showed the presence of silver, arsenic and sulphur. The physical characters as a whole, prevent the mineral from being referred to proustite or xanthoconite, the mineral being nearer like the former in its physical characters. The specific gravity and hardness have not been determined.

Report of exploration of the glacial lake Agassiz in Manitoba, by WARREN UPHAM. (Part E Annual Report, vol. iv, 1888-9, Geol. and Nat. Hist. Sur. of Canada.) pp. 156, Montreal, 1890.

In this report Mr. Upham has given a more detailed and comprehensive account of lake Agassiz than in any earlier report. The first accounts are found in the reports of the Minnesota survey. A bulletin of the United States geological survey adds much to the available literature of this lake, and occasional references to it elsewhere have made lake Agassiz a familiar term to the student of pleistocene geology.

This report comprises that portion of lake Agassiz in Manitoba which is in the prairie region, but the lake included a large area further east and indefinitely northward which has not yet been examined and which, from the nature of the country, it is difficult or nearly impossible to survey at the present time. Much of this unsurveyed region is wooded and rocky, and it is nearly without human habitation. To trace the beach lines would be difficult and expensive.

Considering the great amount of information, however, which Mr. Upham has now given concerning the nature and the probable cause of this lake it is not so regrettable that the eastern part cannot be reported on.

Mr. Upham has availed himself of every avenue of approach to a solution of the problems involved. Adding to a minute study of the drift-sheet itself both in Dakota and in Manitoba, a mass of definite data from railroad levels, he proceeds to the study of common wells and the molluscan fauna which some of them have brought to light. He gives a "history of lake Agassiz," a description of the topography of the basin, its beaches, deltas and its occasional osars, and attributes the existence of the lake, with its north and eastward ascending beach lines, to a depression of the crust of the earth in that direction united with the cotemporary prevalence of a great ice-sheet which, moving from the northeastward formed a barrier against the water that gathered at its southern margin and compelled it to seek the lowest southward way of escape.

The names of the upper beaches are derived from points in Minnesota where they were first observed; but it is found that each of these beaches becomes divided into two or three, further north, having slightly

different altitude above the sea. There are five of the upper beaches, viz: The *Herman beach* which becomes separable into seven stages, the *Norcross beach* which has two stages, the *Tintah beach*, with two stages, the *Campbell beach*, with three, and the *McCauleyville beach*, with three stages. These upper beaches were all formed while the lake out-flowed southward at lake Traverse, by way of the valley of the Minnesota river to the Mississippi valley. They are traced through Minnesota, Dakota and Manitoba. There are lower beaches, formed by lake Agassiz at a lower stage, and while the water found escape northward—though by what channel or channels it is not certainly known. These lower beaches exhibit a similar ascent toward the north indicating some progressive change in the earth's crust which continued during the whole existence of the lake.

The waters of lake Agassiz rose above the present level of lake Winnipeg about 600 feet during the upper Herman stage, 500 feet during the upper Norcross stage, 440 feet at the upper Tintah stage, 370 feet at the upper Campbell stage, and 325 feet at the upper McCauleyville stage. During the lower stages of the lake, while the discharge was northeastward, the depth of lake Agassiz above lake Winnipeg decreased to 285 feet at the upper Blanchard stage, 240 feet at the Hillsboro beach, 210 during the formation of the Emerado beach, and finally 65 feet at the time of formation of the lowest or Niverville beach. The lake extended northward during its greatest development, to the divide lying on the south side of the English or Churchill river, that is to lat. N. 55° with a long westward arm which ascended the Saskatchawan valley. On the international boundary it extended to the east end of Rainy lake and thence turned abruptly northward, its northeastern limits being wholly unknown, but probably coterminus with the ice-sheet that caused, nurtured and perpetuated it.

The Geological and Natural History Survey of Minnesota, Eighteenth annual report, for 1889. N. H. WINCHELL, state geologist. 234 pages; 11 figures in the text. (Minneapolis, Minn., 1890.) About 60 pages of this report present notes of field observations during 1888 and 1889 by the state geologist, in the iron-producing district of northern Minnesota, in the vicinity of Pokegama falls, in the valley of the Minnesota river, and in the area of the original Huronian rocks north of lake Huron and Georgian bay. The author concludes that the Huronian system, as that term is now defined and used in the Canadian geological reports, comprises three separate formations, namely, in descending order, (1) the true Huronian, as first described and mapped by Murray; (2) the Keewatin, discriminated and described by A. C. Lawson in the region of the Lake of the Woods, to which are referred the rich iron ores of Tower, Minn.; and (3) the Vermilion series of crystalline schists. These formations are stated to be distinctly separated by lithologic differences and by unconformities that have been noted from Vermont to Minnesota, so that they should no longer be classed together without

distinction, at least not under the name Huronian, which in the area of its original description embraced only one part of the series.

Prof. N. H. Winchell makes a timely recommendation, on which it may be hoped that the state legislature will take prompt and efficient action, for the setting apart of some considerable tract of the unoccupied lands in northern Minnesota as a state park. The region about lake Itasca, which is suggested, possesses not only rare natural beauty and diversity with its high morainic hills, majestic pine woods, and sparkling streams and lakes, but also much historic interest from the successive expeditions to reach and explore the sources of the Mississippi.

The later part of this report is by Prof. Alexander Winchell, reviewing "American opinion on the older rocks," that is, below the Silurian system, with quotations from the principal geologists of this country who have given especial attention to these rocks, as Ebenezer Emmons, Douglass Houghton, E. and C. H. Hitchcock, Henry D. Rogers, Hall, Logan, Whitney, Hunt, Irving, Lawson, and many others. This summary is given as the introduction to a full discussion of the Taconic and Archæan systems in the Northwest, which Dr. Winchell hopes soon to publish, based upon his own observations and studies.

The Charleston Earthquake of August 31, 1886. By CAPT. CLARENCE EDWARD DUTTON, U. S. Ordnance Corps. pp. 203-528; plates vii-xxxi; figures 1-41. (Accompanying the ninth annual report of the director of the U. S. Geological Survey.) The first chapter of this very thorough and elaborate memoir gives accounts of the earthquake as written by persons who experienced it in Charleston. Not a building in the city escaped injury, but only few were completely demolished and levelled to the ground. Many illustrations from photographs show the damage done to buildings of different kinds in Charleston, Summerville, and other places, including the ancient churches of St. Michael and St. Philip, Hibernian Hall, the Roper and City Hospitals, and brick and wooden dwellings.

Two epicentral tracts are recognized, the principal one about sixteen miles northwest of Charleston and six miles southeast of Summerville, around which the isoseismal curves are nearly circular, and a subordinate one about thirteen miles west of Charleston, surrounded by elliptic isoseismals with their major axes trending toward the northern or Woodstock epicentrum. The violent upward shocks near these places had the effect to drive into the ground the bases of piers on which houses are built. Other remarkable effects were the formation of fissures and craterlets, the latter being large holes in the sandy and clayey ground of the district, from which water poured up, sometimes in jets to the hight of several feet. Railroad tracks were displaced and bent, and at a bridge it was seen that the opposite banks of the Ashley river were thrown slightly nearer together.

Captain Dutton computes the depth of the principal or Woodstock focus of the earthquake energy to be about twelve miles, with a probable

error of less than two miles; and the depth of the more southern focus, though less definitely known, is believed to have been about eight miles. Both the course of the isoseismal curves and the absence of any apparent changes in the slopes and currents of the streams in the district seem to show that there was no extended faulting movement, shearing the rocky strata along an extent of many miles.

The tremors from the most violent shock, which occurred at 9 h. 51 m. 6 s., very closely, in the evening of August 31st, were propagated at a speed of about three and a quarter miles per second, or nearly 200 miles per minute, to so distant points as Boston, Milwaukee, La Crosse, Keokuk, eastern Arkansas, and New Orleans. They were also felt in Cuba and in Bermuda, the distance to the latter island being almost exactly 1,000 miles. The area within which the motion was sufficient to be noticed, including its oceanic portion, was approximately 2,500,000 square miles. With instrumental observation, such as is obtained in Japan by self-recording seismographs, the disturbance would doubtless have been detected over a much larger area. Because of the general use of the standard time system, and the harmony of the observations giving the time of this earthquake in different parts of the country, the author regards his results for the speed of transmission of the shock as far more accurate than all previous determinations for other earthquakes. And it is noteworthy that this velocity agrees with that which theory indicates for elastic waves in an indefinitely extended solid mass of siliceous material, as captain Dutton thinks the earth to be to the depth of at least a hundred miles from its surface.

A vast amount of detailed information was gathered, mainly through assistance by Mr. Earle Sloan of Charleston and by Messrs. W J McGee and Everett Hayden of the U. S. Geological Survey; but, with most careful study, the question how the earthquake was caused completely baffled the long continued and painstaking efforts of the author to obtain any answer. It seems therefore wellnigh certain that the premises on which his investigations proceeded were somewhere unsound. May not the solid mass of the crust of the earth, while having a physical constitution competent for the transmission of the earthquake shock as observed, be yet much thinner than captain Dutton supposes? If the earth's crust rests, at a depth varying perhaps from twenty to thirty or forty miles beneath its surface, on a heavier viscous or liquid interior of molten rock, or of rock under combined conditions of intense heat and pressure which render it freely plastic, may not strains resulting from slow cooling and shrinking of the interior, and from the transportation of material on the surface by streams, produce faults in the solid crust at such depths and of so limited length as to be manifested by epicentral tracts like those of the Charleston earthquake? This view seems to accord well with the phenomena and distribution of volcanoes, with the great movements of folding and faulting by which mountain ranges have been formed, and with the epirogenic uplifts and depressions which have affected broad areas, as the whole or large parts of continents.

The Geology of Cape Ann, Massachusetts. By NATHANIEL SOUTHGATE SHALER. pp. 529-611; plates xxxii-lxxvii; figures 42-51. (Accompanying the ninth annual report, U. S. Geol. Survey.) The glacial and structural geology of a tract about ten miles long, extending into the ocean on the northeast coast of Massachusetts and including Gloucester and Rockport, is here well described, with abundant illustrations supplied from photographs. Only a single drumlin, Pigeon hill, is found on Cape Ann, but this is a large, smoothly rounded, typical example of its class of till accumulations. Boulders are spread in profusion, on a morainic belt about two miles wide, which trends from northeast to southwest at right angles with the average direction of the glacial striation. They are mostly like the granite aud other bed-rocks of the cape, which are exposed in multitudes of outcrops. There are also narrow bands of excessively rocky moraine, with boulders of all sizes up to ten and twenty feet in diameter piled promiscuously together. The systems of joint planes in the granite and diorite bed-rocks have been carefully studied, and a great number of dikes of diabase and quartz porphyry are tabulated and mapped, mostly along the ocean shore and in the extensive quarries near Rockport.

Formation of Travertine and Siliceous Sinter by the Vegetation of Hot Springs. By WALTER HARVEY WEED. pp. 613-676; plates lxxviii-lxxxvii; figures 52-56. (Accompanying the ninth annual report, U. S. Geol. Survey.) Some of the results of the investigations published in this memoir have been recently given by the author in the GEOLOGIST (Jan. 1891, pp. 48-55). His field of special study has been the Yellowstone National Park, whose hot springs and geysers are forming, through the agency of algæ, extensive deposits of silicious sinter, but at only one locality are they known to be depositing travertine, or calcareous tufa, of any considerable extent. This place is the Mammoth Hot Springs, where the heated waters rising through Mesozoic limestone reach the surface heavily charged with carbonate of lime. The white travertine here mostly deposited upon white filamentary algæ, has a maximum thickness of probably 250 feet, resembling an immense snow-bank, and contrasting remarkably with the pine-clad sides of the narrow valley in which it is enclosed, so that it has been compared by Archibald Geikie to the terminal front of a glacier. The formation of siliceous sinter by plant life is taking place in many parts of the Park, among which the Upper Geyser Basin of the Firehole river is selected for particular description. Forty-eight geysers, including the Giant, Bee Hive, and Old Faithful, are known in this area of about two square miles. The maximum depth of the sinter or geyserite around several of the older vents is about 30 feet. Wherever the hot waters flow, multitudinous tints of red and yellow, green and brown, are produced by the growth of algæ, which thrive best at the temperature of about 140° F., but are able to endure 185°.

The structure of a portion of the Sierra Nevada of California. By

GEO. F. BECKER. Bulletin of the Geological Society of America, vol. ii, pp. 49-74, with thirteen figures in the text; Jan. 10, 1891. This society within the first month after its recent meeting in Washington has published two of the communications received at that meeting, and it is expected that the others will follow in rapid succession. Mr. Becker in this important paper announces his discovery that the uplifting of the Sierra Nevada has been effected by many thousands of faults, varying in amount from a small fraction of an inch to three inches or rarely two or three feet, often well marked by slickensides and by measurable displacement on nearly vertical joint planes or fissures. Granite and diorite, overlain in part by andesite and basalt, form the area studied, which has a length of about 80 miles and width of 30 miles, immediately west of the eastern scarp of the range. The fissure systems and the faulting are referred to the period of andesitic eruptions, which the author here regards as Pliocene. But as he shows that the glaciation of the Sierra Nevada was very recent, and in another paper maintains the authenticity of the many reported occurrences of stone mortars and other implements and of human bones in the deep placer gravels, lava-capped, on the western slopes of this great mountain range, which belong to the date of beginning of this period of disturbance, faulting, and uplift, it seems more consistent to regard all these events as comprised within the Quaternary era, the uplift of the Sierra being probably contemporaneous with the first Glacial epoch. In all the faults observed it is found that northerly walls have moved upward and westward relatively to southerly walls, and that easterly walls have moved upward and southward relatively to westerly walls. The theory that the earth is a solid, highly viscous mass appears to the author to be in all respects compatible with his observations, fully explaining the fissure systems, the faults, and the enormous resistance to tilting which the range has displayed.

The Phosphate Deposits of the island of Navassa. BY EDWARD D'INVILLIERS. Bulletin, G. S. A., vol. ii, pp. 75-84; Jan. 27, 1891. This island, lying between Hayti and Jamaica, is 2¼ miles long and 1⅜ miles wide, rising to a hight of 255 feet. It is of recent geologic age, and is formed of coralline limestone that has undergone elevation. Phosphate earths and rock, which are evidently leached guano deposits, fill irregular cavities and fissures in the surface of the limestone to the depth of about twenty feet. The gray phosphate, found on the lower flat or terrace, 10 to 70 feet above the sea, contains 65 to 70 per cent. of lime phosphate; and the red variety, found on the flat top of the island, contains 50 to 65 per cent. The yield of the gray phosphate is 1,500 to 2,000 tons per acre, and the area originally occupied by it was about 244 acres, more than half of which has been exhausted during the past thirty years of mining; but only about a seventh part of the upper 300 acres of red phosphate has been worked, leaving probably 300,000 tons of this variety.

Geological Survey of Illinois, A. H. WORTHEN, *director; Vol. viii. Geology and Palæontology; edited by* JOSUA LINDAHL, PH. D. *Geology by* A. H. WORTHEN; Palæontology by A. H. WORTHEN, CHARLES WACHSMUTH, FRANK SPRINGER, E. O. ULRICH *and* OLIVER EVERETT; *with an appendix.* One volume of text of pp. 1-9, 1-728 and 1-151, and a volume of LXXVIII plates prepared by E. O. Ulrich, Charles Schuchert, and Charles K. Worthen. Royal 8vo. Springfield; published by authority of the State of Illinois, July, 1890.

This volume, which has been in course of publication for a long time, completes and commemorates the scientific work and the life of its chief author, the late state geologist of Illinois. Dr. Lindahl who was appointed successor to Prof. A. H. Worthen in June, 1888, faithfully and efficiently devoted his efforts to the completion in a thorough and creditable style, of the great enterprise that had been left unfinished by his predecessor, and he has manifested his appreciation of the work and his skill and capacity in editing it.

In the preface Dr. Lindahl takes occasion to recommend the continuation of the geological survey of Illinois, noting particularly the need of preserving the records of deep wells and mining shafts, of a hypsometric survey similar to those of New Jersey, New York and Massachusetts, the determination and delineation of the coal-beds, the water-bearing strata, the characters of the clays and other parts of the drift, the lead deposits which adjoin the state of Wisconsin, physical and chemical tests of the rocks, clays and coals, and finally a work giving the systematic paleontology of the state. The facts that should be brought to light by these investigations he would have embodied annually in a report to the Legislature, thus producing a series of volumes similar to that which is maintained by Minnesota and by New Jersey, and now lately begun by Ohio. There is no doubt that it is the better policy for state surveys to be originated and maintained on that plan, with a calculation that it takes time, and much of it, to gather and compare the data that enter into a final geological report. Some of the early state surveys, considered "completed" when they were closed, would be counted as mere reconnoissances in comparison with the requirements of more recent geological work. Had they been continued for several years longer, at but slight annual expense, they might have been more useful, and probably some of the doubts and discussions which have sprung from those "final reports," would never have appeared. In paleontology Illinois and New York have led all the States of the Union, but in economic geology they are as markedly behind. Therefore it is to be hoped that the people of Illinois will supplement the technical geology which has been so ably conducted by Worthen, by as searching an inquiry into the economic geology of the state. In that way only can they reap in full the reasonable results that may be expected from the work of Worthen. Such economic research should be executed deliberately and thoroughly, and for that, it needs much time and a stated small annual appropriation. The survey then would become a bureau where

would be stored all the available information touching every economic interest that can be thought to belong to the geology of the state.

Of the scientific character and merits of the body of the work we cannot here speak with such assurance and thoroughness as we would like. The authors are mostly well-known geologists, and it is only necessary to mention their names to gain the attention of all who are interested in such scientific work. Mr. Ulrich bears the largest burden of this authorship. Besides adding a large number of new forms to the Spongiæ, he has given a sketch of their structural peculiarities, geological distribution and their classification. In joint authorship with Dr. O. Everett a very rich sponge-bearing stratum of the Trenton formation is worked out. The specimens were collected by Dr. Everett three miles northwest from Dixon, Ill., and are divided among three orders and ten genera. They are found in a shaly layer or a "mud stratum," between heavy layers of limestone, about twenty-five feet above the top of the St. Peter sandstone.

The bryozoa, however, which occupy more than one-half of the body of the book, are treated in great detail and fullness. This part of the volume cannot fail to be considered by paleontologists, for many years to come, one of the chief authorities on bryozoa. Mr. Ulrich has been criticised, but generally by those who but partly understood his views and classification and, of course, always by those who had not seen this presentation of them. For this reason the delay in this volume has been unfortunate for Mr. Ulrich. Here will be found Mr. Ulrich's classification, and its reasons, presented *in extenso*. The memoir does not abound in references to cotemporary literature. We notice two figures, one on p. 401, and one on p. 643, which have before appeared in the Geologist, but there is no acknowledgment of that fact, nor of the earlier publication of the new species which they illustrate.

Mr. Worthen, besides chapters on the drift deposits and on the economic geology of the state, contributed a description of fossil invertebrates, and the crinoids and blastoids are treated by Messrs. Wachsmuth and Springer.

The appendix, which is illustrated by a portrait of Prof. Worthen, is by N. W. Bliss and Charles A. White, and gives a sketch of Prof. Worthen's life and scientific work.

First Annual Report of the Geological Survey of Ohio (Third Organ ization), by Edward Orton, State Geologist. Royal octavo, 323 pages, maps in separate envelope, Columbus, Ohio, 1890.

This report is issued uniform in style of binding and size of pages with the final volumes of the survey which preceded it. The report for 1889 is exclusively devoted to a description and consideration of the marvellous natural gas and oil wells which have been developed in Ohio and Indiana within the last five years. The various questions, of the origin of natural gas and petroleum; the explanation of the pressure under which the gas rushes forth when the drill penetrates the reservoir

containing it; the geological structure of the region and its effect on the distribution of the gas fields; the duration of the gas and the means for measuring and protecting its use are all treated of in a thoroughly scientific and comprehensive manner. Seldom does an annual report contain such an able and entertaining as well as conclusive and convincing treatment of any subject, especially one so new and little studied as this. Dr. Orton's style is easy, and his meaning is never obscure.

Not the least valuable and instructive part of the report is the review of the various theories hitherto proposed for the origin of petroleum and natural gas. These are divided into two classes, Chemical and Geological. Under the head of Chemical theories are mentioned that of Berthelot (1866) which accounted for all natural hydrocarbons by the action of chemical forces on inorganic matter at considerable depth within the earth's crust; and that of Mendeljeff (1877) which "holds that petroleum is never of organic origin, but is as purely a product of chemical affinity, acting on inorganic substances, as a vein-stone or an ore." Both of these chemical theories are found to be inadequate to explain the origin of petroleum.

Under the head of Geological Theories are mentioned those of Newberry, Peckham, Hunt and others, and we find that they all agree in deriving petroleum from organic substances that were incorporated with the strata when the latter were formed. Most geologists hold that vegetable substances have supplied the chief sources, but some count animal remains as also an important source. The two methods in which organic matter may have furnished petroleum are (1) by *destructive distillation* and (2) by *primary decomposition*. According to the latter view, which is the one held by Hunt, the petroleum that the rocks contain was formed when the rocks themselves were formed, and this process of formation therefore ceased long ago in the older rocks. Although Dr. Orton does not adopt fully any of these theories, he looks upon the last one mentioned "with great interest as it furnishes on the whole the best explanation of the facts for which we are obliged to account."

A detailed history of each of the great Ohio gas wells up to date is given and many popular opinions, such as the belief in the eternal duration of the gas supply, the existence of vast subterranean caverns which may open and engulf whole cities, and others equally well-founded are exploded.

LIST OF RECENT PUBLICATIONS.

3. *Papers in Scientific Journals.*

American Journal of Science and Arts, *Oct. No.* Description of the "Bernardston series" of metamorphic upper Devonian rocks, B. K. Emerson; Metacinnabarite from New Almaden, Cal., W. H. Melville; Keokuk beds at Keokuk, Iowa, C. H. Gordon; Experiments on the con-

stitution of the natural silicates, F. W. Clarke and E. A. Schneider (Reviewed in this journal vol. VII, p. 56); Five new American meteorites, G. F. Kunz. *Nov. No.*, Superimposition of the drainage in central Texas, R. S. Tarr; Description of the Bernardston series of metamorphic upper Devonian rocks, B. K. Emerson; Anthophyllite from Franklin, Macon Co., N. C., S. L. Penfield; Pre-glacial drainage, and recent geological history of western Pennsylvania, P. M. Foshay; So-called perofskite from Magnet Cove, Ark., F. W. Mar; Experiments upon the constitution of the natural silicates, F. W. Clarke and E. A. Schneider. *Dec. No.*, Long Island sound in the Quaternary era, James D. Dana; The deformation of Iroquois beach and the birth of lake Ontario, J. W. Spencer; Experiments on the constitution of the natural silicates, F. W. Clarke and E. A. Schneider; Eudialyte and Encolite from Magnet Cove, Ark., J. Francis Williams; Peculiar method of sand transportation by rivers, James C. Graham; Note on the Cretaceous rocks of northern California, J. S. Diller; Fowlerite variety of rhodonite from Franklin and Stirling, N. J., L. V. Pirsson; Some observations on the beryllium minerals from Mt. Antero, Cal.

4. *Excerpts and individual publications.*

On certain peculiar structural features in the Foot-hill region of the Rocky mountains near Denver, Colo. Geo. H. Eldridge. (Phil. Soc. Washington, Vol. XI. pp. 247–274.)

Recent views about glaciers. Alexander Winchell. (Forum, Nov. 1890.)

Notes on Triassic plants from New Mexico. W. M. Fontaine and F. H. Knowlton. (Pro. U. S. Nat. Mus. Vol. XIII.)

A study of prehistoric anthropology:—handbook for beginners. Thomas Wilson. (Rep. U. S. Nat. Mus. 1887–88.)

Results of an inquiry as to the existence of man in North America during the paleolithic period of the Stone age. Thomas Wilson. (Rep. U. S. Nat. Mus. 1887–88.)

5. *Foreign Publications.*

Sitzungsberichte d. k. Böh. Gesell. d. Wissen. Math.-Nat. Classe. 1889, contains: Ueber die Fundorte der Mineralien und nutzbaren Gesteine in Britisch Ost-Indien. O. Feistmantel; Ueber Calomel aus Serbien und Realgar aus Bosmien. Dr. K. Vrba; Ueber Camerospongia monostoma. Röm., V. Zahálka; Ueber die Minette und den Gneis von Kuttenberg. Prof. J. Vyrazil; Ueber dikotyledone Pflanzen aus der Potomac Formation in Nordamerika. O. Feistmantel; Beiträge zur Krystallisationstheorie, F. Wald; Ueber Monocalciumphosphat, J. Skolasa; Ueber Bertrandit-Zwillinge, Dr. K. Vrba; Ueber den Diadochit und Delvauxit von Wysocan, Winor und Auwal, F. Kovar; Ueber Pflanzenpetrefakte aus den Stormbergschichten Südafrikas; Ueber de Natur und Eigenschaften des Monocalcium phosphates. J. Stoklasa; Ueber eine neue fossile Spongie, V. Zahálka; Geologische Bemerkungen über das Carbon von Kladno. J. Kusta; Abdrücke im tertiären

Thon bei Satkan nächst Saaz, J. Kusta; Ueber Geröllе aus der Steinkohle von Kroucova. Studnoves und Schlau, J. Kusta; Zweites Verzeichniss der tertiären Pflanzen aus dem plastischen Thon von Preschen bei Bilin, J. Kusta.

Description géologique des iles de Mételin et de Thasos (mer égée), Par L. De Launay (ext. des Archives des Missions (3e ser.) T. XVI.

Annual progress report of the geological survey (Queensland) for the year 1889. R. L. Jack, Townesville, Aus.

Franklinhaynit, ein neues Mineral aus der Wittichenitgruppe. Rudolph Scharzler (aus dem Jahr. d. k. k. geol. Reichsan; XL. B. 3. u. 4. Heft, Wien. 1890).

Die optischen Constanten des prismatischen Schwefels bei verschiedenen Temperaturen. Alb. Schrauf, in Wien. (Sep-ab. aus Zeit. f. Krys. Leipzig. Engelmann. 1890.)

Scientific proceedings of the Royal Dublin Society. Vol. VI., part 8, contains: Note on the magnetic properties of basalt, W. F. Barrett; On some Epi-diorites of N. W. Ireland, J. S. Hyland; On the mesolite of Kenbane head, J. S. Hyland; On some spherulitic rocks from Co. Down, J. S. Hyland; On some specimens from Wady Halfa, upper Egypt, J. S. Hyland; Notes on some assays for gold of rocks occurring in the neighborhood of Dublin, Jos. P. O'Reilly.

Berichte d. nat. wiss. Ver. zu Regensburg, II. Heft, 1888--89, contains: Mineralogische und petrographische Nachrichten aus dem Thale der Ribeira de Iguape in Südbrasilien, H. E. Bauer; Ueber die Umbildungen des Säugethierskelettes und die Entwicklungischte de Pferde, Dr. Roger; Beiträge zur Kenntniss der Regensburger Kreideformation, Dr. Brunhuber.

Bul. de Soc. Imp. Nat. Moscou. 1889, No. 4, contains: Etudes sur l'histoire paleontologique des ongules—IV., Hipparion de la Russe;—V., Chevaux pleistocenes de la Russe.

PERSONAL AND SCIENTIFIC NEWS.

Dr. James Croll, of the Scottish Geological Survey died on Dec. 15th, 1890, at the age of 69. Failing health had compelled him for some years to withdraw from the active pursuit of his two favorite studies, philosophy his first, and geology his later love. Disabled for the hard physical labor of a millwright—his first occupation—by an accident he turned his attention to science and became so well known that he was made Keeper of the Andersonian Museum in Glasgow. His first work, published anonymously, was the "Philosophy of Theism," but the paper which established his reputation was the first of that remarkable series on "The Physical Cause of the Change of Climate during the Glacial Epoch" with which his name will always be associated. It is scarcely necessary here to do more than mention their purport.

Dr. Croll, dissatisfied with terrestial causes, boldly reached out and sought in the varying eccentricity of the earth's orbit a sufficient cosmical cause. It is not too much to say that no speculation connected with this subject has been more fruitful of result or more stimulating to investigation than this. Captivating and fascinating, however, as it was at first, all the argument of its able author could not establish it on a secure base and he was led by his enthusiasm into the adoption and promulgation of views which, in cold light, now appear somewhat extreme. His theory is no longer accepted, at least by most American geologists, being contrary to all the positive evidence afforded by glacial phenomena on this continent, but like many others it will ever remain a splendid monument to the reach and power of the intellect of Dr. Croll, by whose death theoretical geology loses a strong and able investigator.

THROUGH THE INSTRUMENTALITY OF DR. HANS REUSCH, Dr. Winchell's work entitled "Shall We Teach Geology?" is being translated and republished in the *Dagbladet*, Christiania. It will subsequently be used by Dr. Reusch in his classes in his "Seminary of Geology," in the University of Christiania.

DISCOVERY OF FISH REMAINS IN LOWER SILURIAN ROCKS. At a meeting of the Biological Society of Washington on February 7th, 1891, Mr. Charles D. Walcott, of the U. S. Geological Survey, announced the discovery of vertebrate life in the Lower Silurian (Ordovician) strata. He stated that "The remains were found in a sandstone resting on the pre-Paleozoic rocks of the eastern front of the Rocky mountains, near Canon City, Colorado. They consist of an immense number of separate plates of placoganoid fishes and many fragments of the calcified covering of the notochord, of a form provisionally referred to the Elasmobranchii. The accompanying invertebrate fauna has the facies of the Trenton fauna of New York and the Mississippi valley. It extends upward into the superjacent limestone and at an horizon 180 feet above the fish beds, seventeen out of thirty-three species that have been distinguished are identical with species occurring in the Trenton limestone of Wisconsin and New York.

"Great interest centers about this discovery from the fact that we now have some of the ancestors of the great group of placoderm fishes which appear so suddenly at the close of the Upper Silurian and in the lower portion of the Devonian groups. It also carries the vertebrate fauna far back into the Silurian and indicates that the differentiation between the invertebrate and vertebrate types probably occurred in Cambrian time."

Mr. Walcott is preparing a full description of the stratigraphic section, mode of occurrence and character of the invertebrate and vertebrate faunas for presentation at the meeting of the Geological Society of America, in August, 1891.

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GEOLOGY OF THE MOTHER LODE GOLD BELT.*

By HAROLD W. FAIRBANKS, B. S., San Diego, Cal.

The term Mother Lode is used to designate a series of gold bearing veins, of great magnitude, forming a continuous line over a hundred miles long through the counties of Mariposa, Tuolumne, Calaveras, Amador and El Dorado, Cal. They usually occur in a belt of black slate, with either slate, diorite, diabase, serpentine or, occasionally granite as wall rock, and are distinguished by a peculiar green vein-matter, known as mariposite, and by the more or less ribbon-like character of the quartz.

As far as can be learned the term "Mother Lode" was first applied to the veins worked at Nashville, twelve miles south of Placerville, El Dorado county, in the latter part of 1850 or earlier part of 1851.

In the use of the term Mother Lode it is not intended to convey the idea of a genetic relation to other lodes or veins, though it is likely that, from the size, extent, and richness of this series of veins the early miners first used the expression partly with that signification, and partly perhaps, meaning the source from whence came the great wealth of the surface placers.

The magnitude of the operations on the Mother Lode gold belt since the earliest days of mining in the state and the importance of a thorough knowledge of the occurrence of its ores, is best illustrated by the fact that over the whole length of the Lode, 112 miles, there is an almost continuous series of mineral locations,

*Condensed from an article on the geology of the Mother Lode region in the 10th annual report of the State Mineralogist of California.

comprising nearly five hundred patented claims and almost as many unpatented ones.

The Lode follows, in a general way, the northwest and southeast trend of the Sierra Nevada mountains. The veins invariably conform to the strike of the rocks but not to the dip. The dip of the latter varies from fifty to ninety degrees, while that of the veins is from forty to eighty degrees. In direction it ranges from north 60° west to a little east of north in places. The elevation is that of the middle foothills, being as low as seven hundred feet in the river cañons. In Mariposa county it is two thousand feet, and in the northern part of El Dorado county two thousand four hundred feet.

The surface of the region traversed by the lode varies greatly; near the rivers it is cut up by deep, rocky cañons, overgrown with brush and generally quite difficult of exploration, while back some distance the country is rolling or hilly, more free from brush and more or less timbered.

The topography and other physical aspects appear in striking accord with the geologic structure. The foothill region is one which may be styled metamorphic. The more or less altered strata of slates, schists and sandstones being usually in excess of the eruptive rock. It is characterized by ranges of hills running parallel with the axis of the mountains, and often having between them long, deep valleys, or where the rock is of comparatively uniform hardness the hills and valleys are irregularly disposed.

The larger rivers flowing from the high Sierras follow a comparatively direct course to the San Joaquin valley. At times their channels will lie for several miles in the strike of the softer strata, and when a stratum of hard crystalline rock is encountered, they turn and take the shortest course through it. Their cañons are deep and narrow, with scarcely any bottom land. The tributaries of the main streams have generally cut their courses in the strike of the rocks when there exists any decided difference in the hardness of the strata.

Ordinarily this middle foothill belt is well watered; springs are numerous, and a large part is susceptible of cultivation. Timber is quite abundant, sufficient for ordinary purposes, though material for good lumber is to be found mostly higher up. Willow or nut pine, black pine, live oak, and white and black oak are the principal trees; while manzanita, chaparral, scrub oak, greasewood,

buckeye and poison oak are the most prominent of the smaller growths.

The ascent from the plains of the San Joaquin valley is gradual, each succeeding valley being a little higher. South of Mariposa county the slope up to the crest of the Sierras is much more rapid, and with but little intervening sedimentary strata however the sedimentary strata widen quite abruptly in Mariposa county, and in El Dorado county they reach a width of forty or fifty miles.

The Mother Lode occupies about the centre of what is called by Whitney "the auriferous slate belt." The nearly level Tertiary rocks rest on the edge of the upturned slates which are penetrated by many dikes and granite masses. Farther east the slate finally disappears and granite becomes the prevailing rock. However, it must be borne in mind that over a part of the western slope, what is usually called the metamorphic area is formed largely of truly eruptive rocks, which have become so much obscured in character, through various metamorphic agencies, as to appear bedded and of sedimentary origin.

The age of none of these rocks, except the horizontal strata, has been positively decided; a part of these are late Cretaceous and a part are Tertiary. It is probable that the upturned slates are of Jurassic age or early Cretaceous as affirmed by G. F. Becker, while the granite by which they are upturned, intruded and metamorphosed, can hardly be considered Archæan though it has often been mapped and described as such.

As regards the stratigraphical relations of the different members of the series as well as the paleontological evidences more will be said at the close of this article.

So scanty are the fossil remains over a large part of the foothills, and so violent have been the disturbances of the strata that the region is one of uncommon difficulty. However within the last year new locations of fossils have been discovered in the limestone areas along the lode where hitherto all efforts in that direction have been futile. Whatever may be the character and value of the gold deposits in Fresno county it is certain that the southern end of the Mother Lode lies in Mariposa county. A great mass of eruptive granite extends down from the high Sierras, cuts across all the other formations, both sedimentary rocks and dikes, and terminates five miles west of the town of Mariposa. The dikes as a usual thing do not extend up to the granite, but

the schists and slates abut against it for a distance of twenty miles, and in the vicinity of the eruptive mass they are greatly broken and metamorphosed.

The region traversed by the Mother Lode is one characterized by vertical or steeply inclined rocks which are either eruptive dikes or sedimentary strata. Each of the four formations, granite, slate, serpentine, and diabase is characterized by a different surface and soil. The two formations to which the most important topographical features owe their existence are the long, narrow bands of slate and the adjoining diabase dikes. The uniform conformability of these great dikes to the stratification of the sedimentary rocks, their hard and indestructible character, and their juxtaposition with the soft, easily eroded slates, have given rise to those long, deep and narrow cañons leading down to the main rivers that cross the lode.

In Mariposa county, only, does the diabase appear in any great amount on the east side of the lode; there it forms the Mount Bullion range, which rises four thousand two hundred and fifty feet. Bear mountain, of Mariposa county, and its continuation north in the high ridge west of moccasin creek; the Bear mountain range of Calaveras county; the low ridge through Amador county; and the high hills west of the north fork of the Cosmunes river in El Dorado county are the prominent features of this rock west of the lode. This diabase forms a continuous dike west of the black slates through Mariposa county. In Tuolumne county it is broken for a short distance, and near the northern border of the county it appears three miles west of the lode. This is due to a longitudinal compression, the effect of which is also seen in the slates which bend nearly as much in the same direction and away from the course of the lode which pursues nevertheless a nearly direct though less regular line. The serpentine also partakes of the westward deflection, but its massive character indicates that this peculiar position was assumed at the time of the outburst and was not induced by the subsequent folding, for in the latter case it would have been rendered fissile. This is interesting as it gives a clue to the sequence of events in the history of these rocks. Near the northern edge of Calaveras county the black slate is again found in the course of the lode, and it is not only bordered on the west by the diabase but the latter forms many parallel dikes in it. The quartz ledges usually appear at the contact of these two formations.

The diabase extends through Amador county in several parallel dikes, the western one of which is nearly two miles wide. In El Dorado county it gives place for a number of miles to a beautiful syenite porphyry, which in turn is replaced north of Placerville by irregular discontinuous dikes of diorite and diabase to the middle fork of the American river, where these dikes become very numerous and in conjunction with serpentine finally take the place of the black slates. As the Mother Lode approaches this point it becomes less distinct. There being no confining bodies of rock, on the east the veins spread out in the schists where they are usually barren. At Oregon Bar the Mother Lode may be considered as really terminating. Here all its characters are lost and the gold instead of occurring in quartz is found in clay seams in the decomposed crystalline rocks.

Although at times the diabase seems to blend into the adjoining uncrystalline schists and frequently shows lamination yet it can be considered nothing else than an eruptive rock, for in many places it has an amygdaloidal structure. The amygdules occur both in the massive portions and in the matrix of the conglomerates. The fragmental portions, which occur over nearly the whole extent of the outburst, have been classed as tuffs or metamorphic conglomerates by former geologists, but this is incorrect if we accept Rosenbusch's definition of a tuff.

Serpentine is one of the rocks almost always associated with the Mother Lode, sometimes forming one of the walls for many miles. Its influence does not tend to produce a well defined vein, the quartz bodies being almost always bunchy and irregularly placed. When the serpentine occurs in bodies of great thickness it is generally massive, but the long, narrow, dike-like forms are laminated. From the appearance of the lamination it is evident that it has been produced by pressure and movement and is not due to original sedimentation. G. F. Becker, in his report on the quicksilver deposits of the Pacific slope, has advanced the theory that all the serpentine of the coast range has been derived from sedimentary rocks, chiefly sandstones, through metasomatic processes, and that those of the gold belt have originated in the same manner. As far as my observation in the Mother Lode region has gone I see not the slightest reason for attributing to it any such origin.

The occurrence of the serpentine in long, narrow bodies intersecting the slates and crystalline rocks, and in bunches in the

slates which have been pushed aside by them, offers an insuperable barrier to this theory, as does also the almost universal presence of traces of crystalline structure and the frequent occurrence of amygdules.

Dikes and bosses of granite occur at intervals along the lode near Jacksonville, Tuolumne county, the fissure has broken through a knot of granite one thousand feet across.

Many dikes of talc schist and other less altered ones, which still show crystalline structure, are to be seen along the lode, especially through the northern part of Mariposa county.

In Calaveras county, a short distance from the lode, there is a hill of knotty talc schist, in which are imbedded small nodular masses of dark, coarsely crystalline rock, composed of calcite, magnetite and a little pyrite. The talc is rendered knotty by aggregations of granular calcite crystals and shows all gradations between an almost massive form in which the arrangement of the calcite pseudomorphs as well as the structure indicate a once crystalline condition, and a very fissile schist in which the calcite crystals have almost disappeared and the talc fibres have only a slightly wavy appearance. The massive portions undoubtedly represent the original structure which, through some inherent difference of certain parts, was preserved, as were the nodules observed so often in the serpentine. Whatever was the composition of this rock, in the process of substitution which has gone on, everything has been replaced by calcite, except the iron. The pyrites owes its origin to percolating solutions, while the small quartz veins which are scattered through the rock may be due to that also or, what is more probable, to the segregation of a part of the silica of the original mass.

As an example of the complexity of the country rock and of the magnitude which the Mother Lode sometimes assumes, Quartz mountain, Tuolumne county, will best serve. "The Mountain" is about six hundred feet wide, nearly half a mile long, and two hundred and fifty feet high. It is formed wholly of quartz and vein matter, the latter consisting of mariposite and dolomitic material. In the middle and forming the summit is a great body of massive quartz. On the west side another nearly as large, and on the east a smaller one. The vein matter between them is filled with a network of small quartz stringers.

Beginning in the east and going west for a mile, the following

succession of strata occur; first, chlorite schist, then six hundred feet of vein matter, containing three ledges of quartz besides several feldspathic dikes, west of this diabase, serpentine, diabase, decomposed rock probably once crystalline, slate, serpentine, slate, serpentine, and diorite.

The greatest exposure of quartz is on the Mariposa grant in Bear valley. It is twenty feet thick and one hundred and fifty feet long at the base, rising eighty feet with a dip of seventy degrees. It presents a smooth, regular wall on its eastern face, but is somewhat cut up by longitudinal seams.

In Mariposa county the lode is characterized by two veins; first, the one extending north from Princeton, through Bear valley, along the Merced river, and constituting the west vein at Coulterville. A break occurs in this vein between the Anderson mine and the Merced river. The other vein, beginning near the head of David's gulch, north of the Merced river, outcrops almost continuously through Coulterville to Moccasin creek. The fissure continues into Tuolumne county, though containing but little quartz for a number of miles. It is widest at Quartz mountain, and here, as well as north and south for several miles, there are two veins, often lying side by side. In Calaveras county it is most prominent at Carson hill, Angel's camp, and in the vicinity of Mokelumne river. Through the centre of the county it is considerably scattered. Through Amador county it is nowhere confined to a single vein, but consists of a series of them, occupying a width, at times, of nearly a mile. The same condition of things exists in El Dorado county. The veins are scattered through the strip of black slates, though the main vein usually occupies the eastern edge.

Opportunity was not given for extended investigation into the mineralogical features of the lode for the reason that such a large number of the mines are not open. Professor Silliman, in an article in the Proceedings California Academy Science, III, 380, 1867, has described several of the rarer metals, among them being tellurides of gold and silver, which are particularly abundant at Carson hill. He also gave the name mariposite, provisionally, to the green, scaly mineral which is so characteristic of the lode. This mineral is an anhydrous silicate, containing the bases—iron, alumina, chromium, lime, magnesia, potash, silicic and carbonic acids, and traces of manganese, and sulphuric acid.

A white crystalline mineral resembling dolomite is associated with the mariposite. It consists of the carbonates of calcium, magnesium, and iron in varying proportions. The iron is generally present in large amounts, forming that variety of dolomite called ankerite, and giving rise to the red oxide so abundant in the surface decay. The iron at times may nearly or quite disappear, forming dolomite, or the calcite may be so nearly lacking that it becomes magnesite. These minerals form the great mass of the vein matter at points where the lode is so enormously expanded, as at the Josephine mine, the vicinity of Coulterville, Piñon Blanco, Quartz mountain, Whisky hill, Raw Hide mine, Carson hill, and Chili creek.

The most interesting fact connected with these minerals as they occur in the vein, is their relation to the character of the inclosing walls. It is very rare that any vein matter is associated with the quartz when the walls of the fissure are slate, diorite or diabase, but it is almost always present when one wall is serpentine, or when serpentine lies only a short distance away; hence, it is natural to believe that there is some relation between the walls and the vein matter. A basic rock, such as that must have been from which the serpentine was derived, undergoing decomposition, would afford opportunity for the liquids circulating through the fissure to abstract such bases as are found in mariposite and the dolomite or ankerite, and under the proper conditions to deposit them. This was my belief during a portion of the field work, but upon further study, in the laboratory, doubts began to arise as to the possibility of these minerals having been formed in that manner,—whether such immense fissures as those demanded by the amount of vein matter could have existed. If it be urged that the space between the walls need not have been so large at any one time, and during a gradual opening the filling kept pace, then, where are the signs shown in the structure of the deposit? The vein matter is absolutely massive; there is no trace of a banded or bedded structure, and it would seem necessary that such a structure should exist, to a greater or less degree, in deposits on the walls of a fissure, either by reason of the successive additions, in which it would hardly be possible that the currents would be uniform, or the conditions the same through protracted intervals; or by successive openings and closings of the fissure, in which case more or less of the wall material would adhere to the matter de

posited, and thus cause a banded appearance. This is exemplified in vein quartz, which shows a slight banded structure even when massive, and in the division of most of the great quartz deposits into layers more or less thick, with talcose material between them. To account for the phenomena, I wish to advance an entirely different theory, against which I do not see that any valid objection can be raised. It is this: That those portions of the lode so enormously expanded are simply coarse, basic dikes, of no great regularity or continuity, which, lying in the course of the fissure, have been acted upon in a peculiar way by the penetrating liquids and gases. These, through metasomatic processes, have removed part of the original constituents and substituted others. A strong confirmation of this theory is found in a large body of unquestionably eruptive rock, near Jamestown, Tuolumne county, and about half a mile from the Mother Lode. It has very much the same appearance as the vein matter of the lode; except that there is no mariposite. It is seamed with small veins of quartz and in surface decay produces the same red oxide of iron. The only real difference is that the process of substitution is not so complete as in the Mother Lode. Dikes that have undergone a partial change often occur penetrating the Mother Lode vein matter, and at times they are slightly impregnated with mariposite.

An additional reason for adopting this theory is found in the sudden and great expansion and contraction of the lode, as on Moccasin creek, where it widens from only a gouge seam to fifty feet in the course of a few rods. In a small vein, where the expansion and contraction are only a few yards apart, the variation in width can easily be accounted for by a movement of the walls sufficient to bring two prominences or two hollows together. However, this cannot be possible in the case of the Mother Lode where they are sometimes separated by only a gouge for a mile or more and then for a distance of half a mile spread to a width of several hundred feet.

Although it is rare to find any mariposite or ankerite where serpentine does not form one wall, yet there is an exception in the case of a long barren vein, which extends north from Oregon bar ten miles into Placer county. It has a width of forty feet, and contains these two minerals in large amount.

The veins of the lode dip, almost invariably a few degrees less than the inclosing rocks, and it is usual to find the foot wall rocks,

especially when slate, bent away from the normal dip, corresponding with that of the vein; hence, it is probable that the hanging wall has been pushed up. If this is the case it would indicate an upward strain along the mountain range which tended to relieve itself in the fissure of the lode.

That the lode is a true fissure vein is amply proved by the universal presence of gouge seams. The movement of the walls of some of the fissures has been immense. This is made easy on account of their length. The great width of ground-up wall rock and quartz, sometimes forty feet, indicates a long continuance of the movement, probably more or less oscillatory, and with a general rise of the hanging wall. The greatest depth to which the lode has been opened (twenty-two hundred feet) shows no weakening of the vein or deterioration of the ore. It is not likely that any great degree of heat would be encountered at any depth that could be reached, for thus far no increase in temperature has been noticed.

In studying the occurrence of gold and its ores in the Mother Lode, no relation has yet been found to exist between the character of the walls and the poverty or richness of the quartz. It is recognized that a vein lying at the contact of two dissimilar formations is more regular, and that the mineral contents are more easily distributed than in one lying in a formation which does not easily afford a regularly defined fissure.

I do not believe that in the case of the Mother Lode, the mineral character of the walls has influenced the deposit; that is, in the sense of the mineral contents having been derived directly from them. The mines of the lode are equally rich whether in slate or at the contact of slate with diabase, diorite, or serpentine; and poor mines may be found with any of these conditions.

I do not think that any combination of wall rock will insure a rich vein, but that the deposit of the metallic particles is dependent more upon certain chemical reactions taking place in the solutions or vapors circulating in the fissure. This is proved by the fact that of two veins lying side by side in the same mine, one may be barren while the other constitutes the pay rock. What appears as walls on the surface or at any depth which can be reached is no indication whatever of the character of those deep-seated portions from which the circulating fluids abstracted their mineral contents.

The real conditions are certainly complex, differing greatly in

different locations; the same character of ore is rich in one spot and poor in another, without any apparent reason for it.

Any one mining district is apt to be characterized by certain peculiarities, and a study of these is the best guide to go by in that district but they may be misleading in another.

Very little that is new can be said concerning the age of the metamorphic rocks inclosing the lode. The range of opinion has been very great. T. S. Hunt would carry them back as far as the Huronian, while G. F. Becker believes them to be of the same age as the Knoxville group of the coast range, that is Neocomian or lower Cretaceous. The rocks have been generally classed as Jurassic on account of the presence of one or more species of the genus Aucella. This genus has a narrow range, not being known earlier than the Jurassic. It has been found in abundance in strata of the coast range, proven to be Neocomian, hence, doubt is thrown on the generally accepted belief. Some other fossils have been found in the slates but none so characteristic as the Aucella.

Triassic as well as Carboniferous fossils have been found in the northern Sierras, but no one has yet been able to correlate these formations, either limestone or slate, with similar formations in the middle Sierras. The evidence of fossils recently found in limestone in Tuolumne and Calaveras counties is supposed to favor the Carboniferous rather than the Jurassic. The fossils are few and quite fragmental, and it seems to me that the evidence is not yet sufficient to classify the limestones of the middle Sierras as Carboniferous. As far as all observations have yet been carried there has been found no unconformity in the sedimentary rocks of this region; they appear to have been tilted up en masse.

Whitney says that a carefully constructed section along the line of the Central Pacific Railroad furnished no proofs of folds. Since limestone occurs on both sides of the Mother Lode how can it be possible that it should be Carboniferous while the black slates of the lode are Jurassic or Neocomian? If we suppose a downward fold the slates might occupy the center and the strata on either hand be similar, the older, farther away.

The dip of the rocks is nearly always at a high angle toward the mountain range. From every appearance I believe this represents not simply a tilting up but an overthrow. This being the case, the younger strata should be found in the lower foothills, the older, higher up.

The relative ages of the strata, inclosing the Mother Lode, can be ascertained with some accuracy. Of the five most common rock species: slate, diabase, serpentine, granite and syenite, the slate is the oldest, and all the others have been intruded through it after its elevation. It has been pushed aside and more or less broken by each of the others, and frequently portions are inclosed in the crystalline masses.

Of the two, serpentine and diabase, the former though representing the extreme stage of decomposition, is the younger. The proof of this may be found in the intrusion of a long, narrow dike of serpentine through the diabase of mount Bullion. The age of all the diabase dikes is proximately the same, judging from their lithological similiarity, position, and the amount of dynamical metamorphism undergone.

It is difficult to account for the great amount of conglomerate which almost always forms a part of the diabase. It has been shown conclusively that it is not of sedimentary origin, by the presence of amygdules in the matrix as well as in the pebbles. It has not the character of a friction-breccia for it does not always appear near the edge of the dike, and the greater portion of it consists of rounded pebbles, the fragments of petrosilex alone being angular. Neither is it possible that the fragmental character is the result of a surface outburst, for the portions exposed at present were perhaps thousands of feet below the surface at the time of the intrusion. It must then have resulted from the breaking up, at a great distance below the surface of a body of previously existing diabase, the fragments of which were moved about in the molten mass till rounded. The presence of diabase pebbles in the sedimentary rocks can only be accounted for by the supposition of the existence of a body of diabase previous to the present one.

The age of the granite is certainly less than that of the slates and probably less than that of the serpentine; not only are the contact phenomena well illustrated in the outburst of the granite through the slates but the serpentine is bent out of its normal position so that it forms nearly a semicircle.

The large areas of gneiss lying east of the lode are undoubtedly of metamorphic origin. In them the bedding planes represent those of the original sediments. The gradual change of these gneisses into an uncrystalline schist, and their correspondence in dip and strike to the schists are also strong evidences of such an origin.

It may be seen from the foregoing statements that the crystalline rocks must be younger than the slates, and hence it is decidedly erroneous to classify them as Archæan. The granite cannot be considered metamorphic, for whatever was its original condition its present one is that of a truly eruptive rock.

The formation of the Mother Lode is the final event in the history of these rocks. No dikes intersect it and the fissure has broken through all the formations that lie in its path.

The alterations which the rocks have undergone are remarkable. The pressure created during the mountain making movements has been the chief factor in producing this result. The rocks are nearly all laminated, the exceptions being the granite and portions of the serpentine and diabase.

The coincidence of the original bedding of the clastic rocks, with the schistose structure produced by pressure is a source of great difficulty in distinguishing their origin. This is quite remarkable in the case of the black slates in which it is shown, by the position of the fossils, that the cleavage has not been superinduced by pressure but is that of the original sedimentation. It is likely that a far greater portion than is usually supposed of the so-called metamorphic rocks are really eruptive.

No detailed microscopic examination of the Mother Lode rocks has yet been made, however some general facts have been elucidated. The feldspar of the granite and some of the dikes is comparatively fresh, but with these exceptions the decomposition is so great that it is impossible to determine the species of plagioclase feldspar or distinguish it from orthoclase. Distinctly orthoclase feldspar appears only in small amounts even in the granite. While the rocks as a whole are equally remarkable for the almost entire absence of quartz. In but few instances was there noticed any tendency toward the separation of distinct feldspar crystals in the diorites or diabases. In the diabase the augite is almost always present in idiomorphic crystals. They exhibit a beautiful zonal structure and in their decomposition are bordered by fibrous green hornblende. The greenish matrix is decomposed and indefinite in character. The hornblende of the diorites does not usually appear in well-formed crystals.

The serpentine always shows its derivation from a former crystalline rock. It is not certain what the character of that rock was, though from traces of a bronzy lustre in the former pyroxene

crystals it is inferred that the rock was related to the norites. In one case strongly marked transitions from the ordinary diabase to serpentine was observed. Olivine has been detected only in very small amount.

HISTORY OF LAKE AGASSIZ.

By WARREN UPHAM, Somerville, Mass.

From Part E. of the annual report of the Geol. and Nat. Hist. Sur., Canada, 1888-89.

II.

The foregoing observations show that the ice-sheet was melted away from at least half of the area of lake Agassiz during its Herman stages. During the ensuing Norcross, Tintah, Campbell, and McCauleyville stages, through which the lake continued to outflow southward by the river Warren, the recession of the ice doubtless permitted it to extend north and east beyond lake Winnipeg and along the lower valley of the Saskatchewan. Each of these stages is represented by two or three beaches in northern Minnesota and North Dakota and in southern Manitoba, which, with the seven beaches of the Herman series, make seventeen shore lines recognizable in that part of the lacustrine area belonging to the time of its southern outlet. Between the Herman and Norcross beaches the channel of the river Warren was eroded about 25 feet; it was deepened 15 to 30 feet more at the time of the Tintah beaches; 10 to 20 feet farther down to the Campbell beaches; and again 10 to 20 feet to the McCauleyville beaches. In all, the mouth and southern end of the lake were lowered about 100 feet between the highest Herman beach and the lowest McCauleyville beach. Proceeding northward, the vertical distance between these beaches gradually increases to 240 feet on the international boundary, the difference of 140 feet more than the depression caused by erosion of the outlet being attributable to the northward rise of the land and subsidence of the water-level.

Before lake Agassiz could obtain an outlet to the northeast, the thick ice-sheet that had filled the basin of Hudson bay was so far melted as to admit the sea, which at first covered the land west of James bay 350 to 500 feet above the present sea level. Eleven stages of lake Agassiz are marked by beaches that lie below the beds of lakes Traverse and Big Stone, which were the channel of the river Warren when the lake ceased to outflow to the south.

These beaches are separated by vertical intervals that vary from 10 to 45 feet through the range of elevation between the lowest McCauleyville beach and lake Winnipeg, which was originally twenty feet higher than now. As soon as the ice upon Hudson and James bays and the adjoining country had so receded as to give to lake Agassiz an outlet lower than the river Warren, it began to be drained in that direction, perhaps flowing at first across the water-shed between the Poplar and Severn, and later along lower courses, including the canoe route by the Hill and Hayes rivers. Each of its successive outlets was probably eroded to a considerable depth, being occupied by the outflowing river during the time of formation of two or more beaches, until the retreat of the southeastern border of the portion of the ice-sheet remaining west of Hudson bay finally permitted drainage to take the course of the Nelson, the ice-dammed lake Agassiz being thus changed to lake Winnipeg. The northeastern outflow commenced when the lake at the latitude of the south end of lake Winnipeg stood about 1,000 feet above the present sea level, and it was gradually lowered to 730 feet when the Nelson between its successive lakes began to erode the shallow channel of the upper part of its course.

Fossils have been found in the deposits of lake Agassiz at two localities. They are all fresh-water shells of species now living in this district, occurring in beach ridges where excavations have been made to obtain sand for masons' use. The Campbell beach, about six miles southwest of Campbell, Minnesota, at an elevation approximately 985 feet above the sea, has thus yielded shells of *Unio ellipsis* Lea, a common species of the upper Mississippi region. In the Gladstone beach, a half mile northeast of Gladstone, Manitoba, about 875 feet above the sea and 165 feet above lake Winnipeg, four species occur in considerable abundance from two to four feet below the surface, namely, *Unio luteolus* Lamarck, *Sphærium striatinum* Lam., *Sphærium sulcatum* Lam., and *Gyraulus parvus* Say. These species from both localities were kindly determined by Prof. R. Ellsworth Call, who states that *Unio luteolus* is one of the most widely distributed representatives of the genus, its range being from Lake Winnipeg to Texas, east to New York, and west to Montana. It is generally abundant in Minnesota. Both these species of *Sphærium* are reported by Dr. Dawson from the Lake of the Woods and Pembina river; and the first is the most common species of its genus in Minnesota, while

its range northward extends at least to Great Playgreen lake and York Factory, where it has been collected by Dr. Bell. The Campbell beach was formed in the later part of the time of the lake's southward outflow; and the Gladstone beach belongs to the middle portion of the time of its outflow toward the northeast, its south end being then about 85 miles south of the international boundary.

Evidences of man's presence in this region during the departure of the ice-sheet have been discovered by Miss Franc E. Babbitt at Little Falls in central Minnesota. A stratum containing many artificially chipped fragments of quartz is enclosed there in the modified drift of the upper Mississippi valley, which was deposited by the floods supplied from the melting ice-sheet in its retreat while it was being withdrawn from northern Minnesota and the Red River valley.* It seems probable therefore that men lived on the shores of lake Agassiz and witnessed the erosion of the channel of the river Warren, the gradual lowering of the lake level and reduction of its area, and its later northeastward outflow to Hudson bay. But this is not left wholly to conjecture, for Mr. Tyrrell informs me that in northwestern Manitoba, at an elevation of 1,135 feet above the sea, he has found sharp-edged fragments of quartzite, chipped by human workmanship, interbedded with the rounded gravel of one of the Campbell beaches.†

If the question be asked how many thousand years ago did the recession of the ice-sheet take place, causing lake Agassiz to fill the Red River valley and the basin of lake Winnipeg, a reply is furnished by the computations of Prof. N. H. Winchell,‡ that approximately 8,000 years have elapsed during the erosion of the postglacial gorge of the Mississippi from Fort Snelling to the falls

* Proceedings of Am. Assoc. for Adv. of Science, vol. xxxii, 1883, pp. 385-390; American Naturalist, vol. xviii, pp. 594-605, and 697-708, June and July, 1884; and Proc. Boston Soc. of Natural History, vol. xxiii, 1888, pp. 421-449.

† Preliminary notes of this discovery, and of the northwestward continuation of the beaches of Lake Agassiz in the district of Riding and Duck Mountains, are included by Mr. Tyrrell in a paper, "On the Superficial Geology of the Central Plateau of Northwestern Canada, read before the Geological Society of London, Nov. 7, 1888, of which an abstract is given in the Geological Magazine, III, vol. vi, pp. 37-38, Jan., 1889.

‡ Geology of Minnesota, Fifth annual report, for 1876; and Final report, vol, ii, pp. 313-341. Quart. Jour. Geol. Soc., vol. xxxiv, 1878, pp. 886-901.

of Saint Anthony; of Dr. Andrews,* that the erosion of the shores of lake Michigan, and the resulting accumulation of dune sand drifted to the southern end of that lake, cannot have occupied more than 7,500 years; of professor Wright,† that streams tributary to lake Erie have taken a similar length of time to cut their valleys and the gorges below their water-falls; of Mr. Gilbert,‡ that the gorge below Niagara falls has required only 7,000 years or less; and of Prof. B. K. Emerson,‖ on the rate of deposition of modified drift in the Connecticut valley at Northampton, Massachusetts, from which he believes that not more than 10,000 years have elapsed since the glacial period. An equally small estimate is also indicated by the studies of Gilbert§ and Russell** for the time since the last great rise of lakes Bonneville and Lahontan. These measures of time, surprisingly short whether we compare them on the one hand with the period of authentic human history or on the other with the long record of geology, carry us back to the date when the ice-sheet of the last glacial epoch was melting away from the basins of the upper Mississippi, of the Red river of the North, and of the Laurentian lakes.

The entire departure of this ice-sheet therefore probably occupied at the most not more than two or three thousand years; and half of this time may measure the duration of lake Agassiz, with the formation of its beaches marking more than twenty-five successive stages in the concurrent subsidence of its surface and rise of the earth's crust, which amounted together to 700 feet on the latitude of the north part of Duck mountain and the middle of lake Winnipeg. But even these short estimates may be too long. The shores of lake Michigan, similar with those of lake Agassiz in the drift of which they are formed, in their north and south trends, and in the adjoining depths of water, have suffered an

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* Transactions of the Chicago Academy of Sciences, vol. ii. James C. Southall's Epoch of the Mammoth and the Apparition of Man upon the Earth, 1878, chapters xxii and xxiii.

† Am. Jour. Sci., III, vol. xxi, pp; 120-123, Feb., 1881; The Ice Age in North America, 1889, chapter xx.

‡ Proceedings, Am. Assoc. for Adv. of Science, vol. xxxv, for 1886, p. 222. "The History of the Niagara River," Sixth An. Rep. of Commissioners of the State Reservation at Niagara, for 1889, pp. 61-84.

‖ Am. Jour. Sci., III, vol. xxiv, pp. 404-5, Nov., 1887.

§ U. S. Geological Survey, Second annual report, p. 188.

** U. S. Geological Survey, Monograph XI, Geological History of Lake Lahontan, p. 273.

amount of erosion by the lake waves during postglacial time which very far exceeds the total erosion that was effected upon the shores of lake Agassiz during all its stages, the proportion between them being surely not less than ten to one; and lake Michigan has a similarly greater amount of beach deposits, which upon a large area about its south end are raised by the wind in conspicuous dunes. This contrast indeed suggests that the duration of lake Agassiz, and the recession of the ice-sheet from lake Traverse to the lower part of the Nelson river, may have been included within less than one thousand years.

Before lake Agassiz began to exist, the receding Minnesota and Dakota ice-lobes had each given place to a large lake on the central part of the area from which they withdrew. By the barrier of the Minnesota ice-lobe a lake having an elevation of about 1,150 feet above the sea was formed in southern Minnesota in the basin of the Blue Earth and Minnesota rivers, outflowing southward by way of Union Slough to the East Fork of the Des Moines. In its maximum extent this lake probably had a length of 160 miles, from Waseca to Big Stone lake, with a width of forty miles in Blue Earth and Faribault counties, attaining an area of more than 3,000 square miles. The continued glacial recession afterward opened lower outlets eastward to the Cannon river, and at the time of the Waconia moraine had uncovered the lower part of the Minnesota valley, permitting the lake to be wholly drained northeastward to the Mississippi.* The modified drift from the retreating ice on the upper Minnesota basin was deposited along the lower half of this valley, filling it with stratified gravel, sand and clay, to a depth 75 to 150 feet above the present river from New Ulm to its mouth, which shows that at least this portion of the valley was excavated in the sheet of till during the interglacial epoch, and remained with nearly its present form through the later glaciation. It seems also probable that the upper part of the channel above New Ulm, occupied by the river Warren at the time of the Herman beaches, remained from such interglacial erosion, so that the first outflow from lake Agassiz was at a level some twenty-five feet below the general surface adjoining lakes Traverse and Big Stone and Brown's valley, being thus approximately marked by the Milnor beach.† As long as streams poured

* Geology of Minnesota, vol. i, pp. 460, 622, 642.

† Compare with Geology of Minnesota, vol. i, pp. 479-485, describing

into this valley directly from the melting ice-sheet, its modified drift, gathered from the ice in which it had been held, continued to increase in depth; but when the ice had retreated beyond the limits of the Minnesota basin, the water discharged here from lake Agassiz brought no modified drift, and was consequently a most powerful eroding agent. By this river Warren the valley drift, so recently deposited, was mostly swept away, and the channel was excavated to a depth lower than the present river. But since lake Agassiz began to outflow northeastward, the Minnesota valley and that of the Mississippi below, carrying only a small fraction of their former volume of water, have become considerably filled by the alluvial gravel, sand, clay and silt, which have been brought in by tributaries, being spread for the most part somewhat evenly along these valleys by their floods.†

Prof. J. E. Todd supplies me the approximate outline of a lake named by him lake Dakota, which occupied the valley of the James or Dakota river contemporaneously with the foregoing, reaching from Mitchell 170 miles north to Oakes and varying from 10 to 30 miles in width.‡ It outflowed southward by the present course of the James to the Missouri. The Dakota ice-lobe, which had filled this valley and in its recession formed the northern shore of lake Dakota, was not therefore the cause of this lake in the same way that the lake in the Blue Earth and Minnesota basin and lake Agassiz owed their existence to the barrier of the ice-sheet in its retreat. The bed of lake Dakota has a nearly uniform elevation of 1,300 feet, or is within ten feet below or above this, throughout its length; and during the glacial recession it was covered by a lake whose shores have now a height of about 1,300 to 1,350 feet, probably ascending slightly from south to north, as compared with the present sea level. Professor Todd states that the surface of this lacustrine area in its southern part, from Mitchell to Redfield, is nearly flat till, but thence northward is sand and lœss-like silt, while considerable tracts of the eastern border of its north part consist of low dunes.

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the chains of lakes in Martin county, Minnesota, which are apparently due to interglacial water-courses that were not wholly filled with drift in the last glacial epoch.

† "The Minnesota Valley in the Ice Age," Proc. Am. Assoc. for Adv. of Science, vol. xxxii, 1883, pp. 213-231; also in Am. Jour. Sci.. III, vol. xxvii, Jan. and Feb., 1884.

‡ This lake is partially mapped by Prof. Todd in Proc. Am. Assoc. for Adv. of Science, vol. xxxiii, 1884, p. 393.

The outflowing James river was cutting down its channel during the retreat of the ice-lobe, and its erosion was so rapid as to prevent the northern part of lake Dakota from retaining sufficient depth to outflow eastward into the south end of lake Agassiz when the way was opened by the further departure of the ice, receding from the Head of the Coteau des Prairies and beginning to uncover the Red River valley. A large tract of the sand and silt beds of lake Dakota, and of a contiguous glacial lake formed in Sargent county, North Dakota, at the time of the Dovre moraine, now sends its drainage to the Red river by the head stream of the Wild Rice, which passes north of the Head of the Coteau and enters the area of lake Agassiz near Wyndmere. The lowest portion of the water-shed on this lacustrine deposit, over which the James river would flow east to the Wild Rice river is scarcely ten feet above the general level of the James valley or twenty-five feet above the present level of the James river, being at Amherst on the Aberdeen branch of the Saint Paul, Minneapolis and Manitoba Railway, 1,312 feet above the sea. The elevation of the upper portion of the lake beds in the vicinity of Oakes, and the lack of evidence that the lake waves have acted at any greater height upon the adjoining surfaces of undulating till and morainic hills, lead to the conclusion that the highest shore line of the north end of lake Dakota is not more than 1,345 feet above the sea, showing that there was only a shallow expanse of water above the plain of lacustrine silt. On the north the depth of the channel of the inflowing James river, eroded apparently before the glacial retreat could permit an eastward outlet into lake Agassiz, indicates that the surfaces of land and water in the James valley had gained nearly their present relations, lake Dakota being already drained away, when the Wild Rice river and the south end of the Red River valley were uncovered by the recession of the ice-sheet. It is evident, therefore, that the long area of lake Dakota has experienced only slight differential changes of level, at least in the direction from south to north, since the departure of the ice. The James River valley is thus strongly contrasted with the northward uplifting that has affected the Red River valley as shown by the beaches of lake Agassiz, the highest of which rises from south to north about six inches per mile for 30 or 40 miles at its south end, but a foot or more per mile within 40 miles farther north, and indeed has an average northward ascent of about

one foot per mile through an extent of 400 miles along the west side of this lake in North Dakota and Manitoba.

As lake Agassiz gradually extended to the north, following the receding ice-barrier, it received successively by three outlets the drainage of the glacial lakes of the Saskatchewan and Souris basins. These streams took the course of the Sheyenne, Pembina, and Assiniboine rivers, each bringing an extensive delta deposit. With the first retreat of the ice from the Missouri Coteau a glacial lake began to exist in the valley of the South Saskatchewan in the vicinity of the Elbow, probably outflowing at an early time by the way of Moose Jaw creek, and through a glacial lake in the upper Souris basin, to the Missouri near Fort Stevenson. Later the outflow from the lake Saskatchewan may have passed to the lake Souris by way of the Wascana river, after passing through a glacial lake which probably extended from Regina sixty miles to the west in the upper Qu'Appelle basin. When the Dakota ice-lobe was melted back to the vicinity of Devil's lake, the drainage of lake Souris passed southeast by the Big Coulée, one of the head streams of the Sheyenne, flowing thence for some time southward by the James river to lake Dakota, but later eastward and southward by the Sheyenne into lake Agassiz. A manuscript report of a reconnoissance in North Dakota by major W. J. Twining, in 1869, describes the valley of Big Coulée as 125 feet deep and a third of a mile wide, enclosing several shallow lakes along its course. "This great valley," he writes "preserves its character to within twelve miles of the Mouse [Souris] river and connects through the clay and sand ridge with the open valley of that stream."

The Sheyenne delta, reaching from the Lightning's Nest fifty miles northwest to the south bend of the Maple river, and having a maximum width of nearly thirty miles to the northeast from the south bend of the Sheyenne, probably covers an area of 800 square miles to an average depth of 40 feet. A large portion of this delta is doubtless modified drift, which was brought down by glacial streams from the melting surface of the ice-sheet, their coarser gravel with much sand being deposited in the high plains, that slope southward along the outer side of the great moraines that pass south of Devil's lake, their finer gravel and sand being carried by the Sheyenne to this delta, and their finest silt and clay being spread in the quiet water of the lake over a much larger ad-

joining area of its bed, from near Breckenridge, northward beyond the mouth of the Sheyenne. Much alluvium was also supplied from the erosion of the Sheyenne valley, which, with that of the Big Coulée, probably averages three fourths of a mile in width and 150 feet in depth along a distance of 200 miles. This channel is cut in the drift sheet, mainly till, and in the underlying easily eroded Cretaceous shales. The volume of the material supplied from it would be equal, according to these estimates, to about three fourths of the Sheyenne delta, or perhaps to three eighths of both the delta and the finer clayey sediments that were deposited farther out in the lake. But the valley of the Sheyenne was doubtless also both a preglacial and an interglacial valley. It was probably wholly filled with till in the first glacial epoch, then was eroded, chiefly in this drift, to nearly its present size during interglacial time, and was partially but perhaps not wholly refilled with till in the last epoch of glaciation. If it retained in considerable degree its trough-like form beneath the last ice-sheet, as was evidently true of the Minnesota valley, its erosion and its tribute to the Sheyenne delta would be less than the proportion estimated.

When the bed of lake Agassiz was gradually uncovered from the water of the receding lake, some parts of its central plain through which the Red river flows probably remained as broad, shallow basins of water, which that river and its tributaries have since filled with their fine clayey alluvium. The similar clayey silt brought into lake Agassiz by its delta-forming affluents, the Buffalo, Sand Hill, Sheyenne, Pembina, and Assiniboine rivers, and others farther north, has been spread over large areas of the lake bed, but more extensive portions had a surface of till, with no such lacustrine deposit. Over these formations, much alluvium has been laid down along the avenues of drainage of the old lake bed, and it has filled depressions of the original surface, whether of lacustrine sediments or of till, being only distinguishable from the former by its containing in some places shells like those now living in the shallow lakes of the country adjoining the area of lake Agassiz, remains of rushes and sedges and peaty deposits, as of the present marshes of the Red River valley, and occasional branches and logs of wood, such as are floated down by streams in their stages of flood. Thus the occurrence of shells, rushes and sedges in these alluvial beds at McCauleyville, Minnesota, 32 and 45 feet below the surface, or about 7 and 20 feet be-

low the level of the Red river, of sheets of turf, many fragments of decaying wood, and a log a foot in diameter at Glyndon, Minnesota, 13 to 35 feet below the surface, and numerous other observation of remains of vegetation elsewhere along the Red River valley in these beds, demonstrate that lake Agassiz had been drained away, and that the valley was a land surface, subject to overflow by the river at its stages of flood when these remains were deposited.* Even at the present time much of the area of stratified clay that almost continuously forms the central part of the valley plain is covered by the highest floods and probably no portion of it is more than ten feet above the high water line of the Red River and its tributaries. The position of the thick beds of fine silt and clay in the central depression of the Red River valley shows that they were not mainly deposited by the waters of lake Agassiz, which must have spread them somewhat equally over both the lower and higher parts of the lacustrine area; but instead appears to prove that at least their upper and greater part was brought by the rivers which flowed into this hollow and along it northward after the glacial lake was withdrawn.

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NOTE.—The author recognizes the undoubted synonymy of some genera and species in the following list, but as some of these have been brought to the notice of the public, no comment or reference, whatever, to any particular case, is here made; indeed, such reference would hardly be in proper place in a bibliography or list of new forms. The list, therefore, contains some forms represented by two names.

Adocus punctatus Msh.	§Cretaceous of New Jersey.	‡34.
Allurodon compressus Cope.	Loup Fork Miocene.	8.
Amblyaspis, gen. nov. Traq.		
A. acadicus Wh.	Devonian of Canada.	48.
Barosaurus gen. nov. Msh.		
B. lentus Msh	Atlantosaurus beds of Dakota.	32.
Brachypsalis gen. nov. Cope.		
B. pachycephalus Cope.	Loup Fork of Nebraska.	10.
Cephalaspis laticeps Traq.	Devonian of Canada.	46.
C. whiteavesi Traq.	Devonian of Canada.	46.
Ceratops (*Hadrosaurus*) *paucidens* Msh.	Laramie of Montana.	32.
Claosaurus gen. nov. Msh.		
C. (*Hadrosaurus*) *agilis* Msh.	Pteranodon beds of Kansas.	30.
Colodon gen. nov. Msh.		

§ Locality or formation.

‡ Refers to number of memoir in above list.

C. luxatus Msh	Brontotherium beds of Dakota.		33.
Diploclonus gen. nov. Msh.			
D. amplus Msh.	Brontotherium beds of Dakota.		33.
Emys euglypha Leidy.	Florida.	*1889.	19.
Felis maxima Scott.	Loup Fork of Kansas.		43.
Glyptodon septentrionalis Leidy.	Florida.	*1889,	19.
Glyptops gen. nov. Msh.			
G. ornatus Msh.	Atlantosaurus beds of Wyoming.		34.
Gyracanthus incurvus Traq.	Devonian of Canada.		48.
Hippotherium princeps Leidy.	Peace Creek, Fla.		23.
Hyopotamus deflectus Msh.	Brontotherium beds of Dakota.		33.
Limnohyops gen. nov. Msh.			
L. laticeps Msh.	Brontotherium beds of Dakota.		33.
Machairodus floridanus Leidy.	Ocalamarion Co., Fla.		20.
Mastodon rugosidens Leidy.	Beaufort Co., S. C.		26.
Ornithomimus gen. nov. Msh.			
O. velox Msh.	Ceratops beds of Colorado.		32.
Phlyctænius gen. nov. Traq.			
P. acadicus Wh.	Devonian of Canada.		46.
Pteropelyx gen. nov. Cope.			
P. grallipes Cope.	Laramie of Montana.		7.
Rhinoceros longipes Leidy.	Peace Creek, Fla.		23.
Stenogale robusta Cope.	Loup Fork of Nebraska.		10.
Teleodus gen. nov. Msh.			
T. avus Msh.	Brontotherium beds of Dakota.		33.
Testudo brontops Msh.	Lower Miocene of Dakota.		34.
T. crassiscutata Leidy.	Peace Creek, Fla.		21.
Trachodon longiceps Msh.	Laramie of Wyoming.		30.
Triceratops prorsus Msh.	Ceratops beds of Wyoming.		32.
T. serratus Msh.	Ceratops beds of Wyoming.		32.
T. sulcatus Msh.	Ceratops beds of Wyoming.		30.

HAS "NEWARK" PRIORITY AS A GROUP NAME.

By Israel C. Russell, Washington.

In a brief paper on the Newark system published in this journal about two years since,* I proposed a revival of "Newark" as a group name for the reddish-brown sandstones and shales and associated trap rocks of the Atlantic coast region, which had previously been quite generally referred to the Triassic and Jurassic. A long list of names was presented that had been used to designate the rocks in question; nearly all of which implied correlation with European terranes, ranging from the Silurian to the Jurassic. The

*Vol. 3, 1889, pp, 178-182.

* Am. Geol. 5, April, 1889, p. 251.

advisability of adopting a name that did not indicate relationship with distant formations was also pointed out. The first name on the list referred to, which met this requirement was, "Newark group," proposed by W. C. Redfield, in 1856. That this was a group name intended to indicate the entire formation, is shown by the language used. Redfield's words are:

"I propose the latter designation [Newark group] as a convenient name for these rocks [the red sandstones extending from New Jersey to Virginia] and to those of the Connecticut valley, with which they are thoroughly identified by foot-prints and other fossils, and I would include also, the contemporaneous sandstones of Virginia and North Carolina."*

As stated in my previous paper, the term "group" has been adopted by the International Congress of Geologists, in a wider sense than was implied by Redfield. I therefore suggest that "system" should be substituted instead. Before offering this suggestion I made what I believe to have been an exhaustive examination of the literature relating to the terrane in question, and concluded that Redfield's name had precedence over all other names that had been used which did not imply correlation.

The term Newark system has recently been adopted by several geologists, in accordance with my suggestion, and up to the present time but one voice has been raised against it. In an article on "The use of the terms Laurentian and Newark in geological treatises," published in this Journal,† Prof. C. H. Hitchcock has formulated five objections to its acceptance. These will be considered in the order in which they were presented.

First. It is claimed that "An essential feature of a name derived from a geographical locality is that the terrane should be exhibited there in its entirety or maximum development;" and that the territory about Newark, N. J., does not meet these requirements for the Newark system.

Without dissenting from the wisdom of the rule proposed, although a large number of exceptions could be found to it in the best geological memoirs, I wish to state from my own knowledge that the region about Newark may be taken as typical of the terrane named after that city. The characteristic reddish-brown sandstones and shales are there well exposed, and in the neighbor-

* Am. Jour. Sci., 2d ser. 1856, Vol. 22, p. 357; also in Am. Assoc. Adv Sci. Proc., Vol. 10, Albany meeting, 1856, p, 181.

† Vol. 5, 1890, pp. 197-202.

ing Newark mountains, the associated trap rock occurs in sheets of great thickness. This statement is sustained by Prof. Hitchcock's own words, a little farther on in the paper cited, where he says "the New Jersey terrane possesses the distinguishing features of the Trias, quite as well as the one in New England."

That *Passaic* would have been a better name as Prof. Hitchcock suggests, is perhaps true, but the one before us was definitely selected and has priority.

Second. It is stated by Prof. Hitchcock that the name "Connecticut or Connecticut River sandstone has priority over Newark," and was used by several geologists before Redfield's proposal in 1856, "though none of them had proposed it as a geological term." The admitted fact that no one had used the name referred to as a geological term, relieves me of the necessity of showing that Redfield's name has priority.

In the writings of the older geologists, among whom Prof. Edward Hitchcock will always take the first rank as an investigator of the sandstones of the Connecticut valley, the terms "Connecticut sandstone" or "Connecticut River sandstone," were used in the same sense as the coördinate term I have just employed, i. e., as a geographical designation; just as they might have referred to the granite of Massachusetts without any intention of proposing a group name. The fact that the older geologists, and among them Prof. Edward Hitchcock, spoke of the Newark rocks of New England under definite group names, implying correlation, is sufficient evidence that they did not recognize the value of an independent name.

Third. It is stated that Prof. J. D. Dana adopted the name proposed by Redfield, in his lectures, but did not use it in his subsequent writings. Prof. Dana's reasons for this course have never been published, and so far as it is a precedent—happily precedents have less weight in geology than in some other professions—it indicates that we should first use the name Newark and then abandon it for other names implying indefinite correlation with distant terranes.

Fourth and *Fifth.* While it is admitted that the terrane under discussion is quite as well represented in New Jersey as in the Connecticut valley, it is claimed that the latter having been studied first, should have furnished the group name. I fully agree with Prof. Hitchcock in this, and could add several other group names

which to my taste might be improved, but the author of a geological name, like the palæontologist who describes a new fossil, is entitled to priority. To attempt to introduce a new name for a group of rocks already sufficiently well designated, would only bring confusion, similar to that produced by the great variety of names implying correlation, that have already been used for the Newark system.

THE POST ARCHÆAN AGE OF THE WHITE LIMESTONES OF SUSSEX CO., N. J.*

FRANK L. NASON, New Brunswick, N. J.

I.

Early in the year 1888, during the progress of my work on the Geological Survey of New Jersey, I was at Franklin Furnace for nearly two weeks. While there my attention was attracted by what I supposed to be boulders of gnéiss in the white limestones. I also noticed the outcrop of sandstone, which appears on the north side of the Furnace pond.

My curiosity was excited and farther search showed other localities as interesting as these. The result was that the idea of these white limestones being the metamorphosed "Blue" first suggested itself to me. I was then ignorant of the attention which this subject had attracted in the past, and supposed that I was the originator of the idea. Further study showed me my error, but I determined to satisfy myself on the subject, especially as it seemed to me that the question in whatever light it was regarded had never been fully settled.

The first paper of consequence, bearing on this subject, appears in the "Journal of the Academy of Natural Sciences of Philadelphia," 1822. The authors, Keating and Vanuxem, have a paper on the "Geology and Mineralogy of Franklin, in Sussex county, N. J." In this paper the writers offer no proof of the Archæan age of this limestone, though as will be seen, the idea is strongly

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* This paper deals only with the principal work that has been done in this area and a part of Warren county, and also a part of Orange county, N. Y. The full results of this work are recorded in the reports and papers quoted.

The more recent work by the writer is published in the Annual Report of the State Geologist of N. J., for the year 1890.

advocated, save the following: A rock which they call sienite, but which cannot be limited to the altered sandstone or to the eruptive granite (since, according to them, it partakes of the nature of both) occurs in beds or layers. These are parallel to the strike of the white limestones. These beds also, according to the writers, dip S. E. with the limestones at an angle of 80°. Subordinate to the sienite they place 1st limestone, 2d gneiss, 3d queenstone (whatever they mean by it). The sienite, limestone, gneiss, and greenstone, are all evidently regarded by them as being of sedimentary origin. Since the greenstones are described by them as being derived from the sienites by an increase of amphibole and a dimunition of feldspar, the greenstones are of limited extent.

It is admitted that although the limestones are subordinate to the sienite, sienite is interstratified with the limestone.

It is noted by them that the principal minerals are found in the sienite in cavities, or at least near to the sienite. They also observe that in the grauwacke and the limestone overlying it there is present "fluate of lime of a pale violet color, which is found in small cavities in the limestone, and appears to have been formed by infiltration into it as well as the rocks under it. It cannot, therefore, serve to connect these rocks with the sienite in the limestone of which it has also been found, or to prove them to have been of cotemporaneous origin, as some geologists have supposed; but this hypothesis is in direct opposition to the fact which we have previously mentioned of its being found resting upon the upturned edges of the sienite."

I quote their words to show the nature of the proof which they advance. Their proof of difference in time of deposition of the blue and the white limestones, rests upon unconformability. This unconformability is shown by pointing out that while the white limestones lie under the sienite, or are interstratified with it, the blue limestones and the grauwacke lie upon the upturned edges of the sienite. The inutility of this argument is at once apparent when it is pointed out that an eruptive granite has been confused with a foliated and bedded rock of a wholly different nature.

They failed to find fossils either in the blue limestone or in the grauwacke, though they have since been found.

The next important paper which I have succeeded in finding bearing upon this subject is the "Report on the Geological Survey

of New Jersey," Philadelphia, 1836. Whether, during the four teen years which elapsed between the publication of the paper just quoted and this report of Prof. Rogers, this question was canvassed and the drift of scientific opinion set in favor of Prof. Rogers, I cannot say. Certain it is, however, that Prof. Rogers in this report calmly takes his position for granted and describes all of these limestones under the name of Formation II. There are numerous papers in the earlier volumes of the American Journal of Science, by Nutall, Pierce, Shepard and others, and these men seem to favor Prof. Rogers.

In these papers, the region under discussion is referred to as the "transition series." No special mention is made of the white limestones but they appear to be included in the same category as the rocks of the Green pond, Bearford, and Bellevale mountains, and the blue limestones of the N. W. border.

Prof. Mather, as will be shown later on, seems to adopt this view, but ascribes to Thomas Nutall the credit of first expressing the opinion that the blue limestones and the white limestones are cotemporaneous in origin.

In the American Journal of Science, vol. v., pp. 247-248, Nutall describes the rocks near Fowler's house at Franklin as follows:

"The crystalline calcareous rock which alternates with granitines of feldspar and quartz, or with beds of sienite granite, disappears, and a confluent grauwacke, almost perplyritic, and cotemporaneous apparently with the other formations, appears directly overlaid by a bed of leaden, minutely granular, *secondary* limestone, containing organic remains of the usual shells and coralines, and layers of blackish hornstone or petrosilex. This rock, as well as the grauwacke *beneath*, presents disseminated crystals of blue fluate of lime. In the limestone the cavities are sometimes very numerous, and lined both with pseudomorphous masses and cubes of blue and white fluate and quartz crystals.

"Thus we have," continues the writer, "here before us, as at lake Champlain, the novel and interesting spectacle of a union of every class of rocks, but passing decidedly into each other as if almost cotemporaneous"!

Nutall's position is thus clearly defined though he makes the usual mistake of supposing the so-called sienite to be of sedimentary origin.

On page 112 of his report, Prof. Rogers first makes mention of the associated limestones and sandstones, and as he calls it, sienitic granite. He however is a little ambiguous for he speaks of it as a bed of sienitic granite of the usual composition of the gneiss of this region, which dips eastward with the other beds, i. e. the white limestones, gneiss and sandstones.

He speaks of the scarcity of organic remains but states that he found madrepores in proximity to the flinty nodules in the limestone.

He says nothing in this report of his idea of the cotemporaneous origin of the white and blue limestones, but as he describes this altered under the head of Formation II, one is at a loss to decide as to what his attitude was on the question.

His section through this point, though, shows the blue limestone and sandstones dipping N. W., the gneiss, beds of franklinite and altered limestone or marble with veins of quartz and sienite dipping S. E. Then the blue limestone which is again represented as dipping N. W.

His only marked error in this section is in representing the blue limestone as keeping its N. W. dip to Hamburg Mt., whereas the N. W. dip is in a short distance succeeded by a S. E. dip, and then the reappearance of the white limestone which reaches nearly to the mountain to the east.

In the "Final Report on the Geology of N. J.," published in 1840, on pp. 47 to 67, Prof. Rogers describes the limestones of Formation II. In these pages the geological features are outlined with such boldness and fidelity to fact as to awaken in one the feelings of profoundest admiration for one who could accomplish so much with the limited time and means at his disposal. Under the title "Formation II," Prof. Rogers describes in detail the blue limestones, "called in N. J., magnesian, in N. Y. calciferous."

In these pages he makes no special mention of the white limestones, but from the locating of isolated patches of Formation II, especially in the low water shed between the Musconetcong and the Wallkill rivers, it becomes very evident that there is no shadow of doubt in his mind but that the two limestones are cotemporaneous in origin.

It is under the heading of "Igneous Rocks Connected with Formation II," that all ambiguity is removed and his position is clearly and positively defined. That there may be no possibility

of mistake, either in the understanding of his words with regard to Formation II or confusion as to locality, I quote from him verbatim: "The blue limestone of the Kittatiny valley, exhibits, in certain localities, some highly impressive and remarkable phenomena of alteration of structure, induced by the heating agency of a series of igneous injections.

"The altered bands of the rock may be grouped into two distinct belts ranging from N. E. to S. W. parallel to the general strike of all of the strata in this quarter of the state. The more northeastern of these belts occupies, at intervals, the valley which lies immediately at the foot of the Hamburg or Wallkill Mt., throughout nearly its whole length, keeping usually towards its northwestern margin, or near the base of the Pochuck Mt., and the belt of hills in its prolongation to the S. W. namely, the hills north of Franklin, Pimple hills and the hills north and west of Sparta and Lockwood. The northeastern tract first shows itself at Mts. Adam and Eve, in New York, about five miles beyond the state line, and has its southwestern termination in the neighborhood of Lockwood.

"Over this whole distance, though the altered material exhibits considerable diversity in regard to the imbedded minerals which it contains, yet the main mass of the rock, or the calcareous paste investing them, remains to a great extent, of a uniform character as to structure and color." Farther on he makes mention of the coarsely crystalline limestones in the following manner. "When destitute, or nearly so, of the extraneous minerals often diffused through it, the prevailing condition of the rock is that of a white, perfectly crystalline limestone. An extreme degree of development of the crystalline structure had assumed the condition of rhombic calcareous spar."

"It is often then semitranslucent, but more frequently it is of an opaque white and occasionally of a pink hue, resembling somewhat reddish feldspar. These varieties may be regarded as the altered rock under its most characteristic features, and are to be viewed as exhibiting *the limit of alteration* of which the limestone has been susceptible by igneous action, when it has been *pure* or consisted of little else than carbonate of lime. When of such aspect and structure the mineral most usually disseminated through it is *plumbago*, in small brilliant plates, often perfectly hexagonal. Beside this highly developed crystallization, it presents every grada-

tion of crystalline structure down to a finely granular one, and even to what may be termed the subcrystalline condition, when it often partakes of the color and texture of the blue limestone out of which all these varieties have originated."

On pages 73 and 76 of this final report Prof. Rogers describes very minutely, two localities in which a change from the unaltered blue limestone to the highly crystalline limestone takes place within a distance of fifty feet.

In one of these localities at Lion pond, now Roseville pond, there is a regular gradation from the S. E. First gneiss, second sandstone Formation I, third, blue limestone Formation II, passing into the sandstones, and finally, the white crystalline limestones in contact with a dike of feldspathic sienite to which he ascribes the cause of alteration.

Another very important fact recorded by Prof. Rogers (in this report, p. 74,) is the presence of the mineral chondrodite in these altered limestones. He notes that the abundance and perfection of the crystallization of this mineral bears a direct ratio to the crystallization of the limestone and this to the proximity to an igneous rock.

I have thus briefly stated the outline of this report by Prof. Rogers. It will be seen that he committed himself unhesitatingly to the idea, first, that granites or sienites were eruptive; second, that these eruptive rocks caused the metamorphism of the blue limestones, in places, to the highly crystalline white limestones of this region.

It does not vitiate the truth of his observations in this case, that he went still farther and assumed the eruptive nature, not only of the granites and greenstones, but of the magnetite iron and of the zinc ores of the highlands of Sussex county especially.

On this basis however he would have had hard work to account for the presence of sphalerite beds in the same limestone belt but nearer the Delaware river.

Even in this brief sketch it is very evident that, however brilliant the conception of this idea of the metamorphism of the blue limestone may have been, it was more in the line of geological speculation, and he fell far short of proving his position, though in comparison with the recorded observations of Vanuxem and Keating his demonstration is perfect. A careful reading of his whole report on this subject does little more than to multiply instances

without going into the details of the matter which an exhaustive and decisive treatment of the subject demands.

This is not written in a spirit of hypercriticism but simply to account for the later adopting of the views advocated by Vanuxem and Keating, though the subsequent adoption of their views was based on errors as great as these geologists made.

While Prof. Rogers was engaged in his work in New Jersey, Profs. Mather, Beck, and Emmons were engaged in a field in New York, very similar to the highland belt of New Jersey, described by Prof. Rogers. This is especially true of the field occupied by Prof. Mather. As is very well known, the crystalline region of southern New York is but an extension of the same belt from New Jersey.

In the report of Prof. Mather, "Geology of New York," part I, vol. iv, it is a little difficult to understand just what he means by a primary limestone, in which he very evidently believes, for in a foot-note, p. 464 of this report, he says: "The true primary limestone here alluded to is the same that forms the second class of metamorphic limestones in this volume, and which is next to be described as the metamorphic limestones of the Highlands and west of the Hudson and of Washington county."

The last paragraph of this same page, summing up the facts of the I division of metamorphic rock, reads as follows:

"After reviewing all the facts observed both by others and by myself, I have been led to the conclusion, that the *limestones that are frequently crystalline, white and variegated marbles* in the western part of Vermont, Mass. and Conn., and in the eastern part of New York, from mount Washington to the city of New York (that have been described in this chapter) are *Metamorphic Rocks*—that they were originally the *Mohawk limestones and Calciferous sandstones*, and that the *associated rocks were originally the Potsdam sandstone and the slate rocks of the Hudson valley;* that they were in fact the rocks of *the Champlain division*, but much more altered and modified by metamorphic agency than *the Taconic Rocks*"*!* The italics and capitals are Prof. Mather's.

On page 465 he describes the second class of metamorphic rocks (true primary?) under the heading "II Metamorphic Rocks of the Highlands, and of Saratoga and Washington counties."

He spent about two weeks in 1828 and 1838 in the study of the white limestones in Orange county, New York, but having been

unfortunate enough to lose his note books, he quotes verbatim in many places the report of Prof. Rogers in the New Jersey geology and appears to adopt his views unquestioningly. He also quotes from Dr. Horton and from Prof. Shepard.

Dr. Horton published his report in 1839 and from the fact that he is quoted by Prof. Mather, it would seem that the views of the two were in accord.

That there may be no mistaking the position of Prof. Mather, I quote from his, p. 465: "In Orange county, New Jersey, and in Sussex county, New Jersey, all the changes from the gray and blue limestone (Mohawk limestone and Calciferous sandstone of the New York reports and formation No. 2 of the Pennsylvania survey) can be distinctly traced into perfectly crystallized limestone, containing the various crystallized minerals; so that it is believed that most of those who will examine the rocks thoroughly, will admit that they are metamorphic."

The puzzling fact in these quotations, more puzzling in the report, is that he seems to regard the marbles, described in the first class of metamorphic, as younger and wholly distinct from the second class of metamorphic rocks in which he includes "the true primary limestones." Yet the Mohawk limestone, the Calciferous sandstone, and the Potsdam sandstone appear in each division.

One thing is very evident, he believed thoroughly in metamorphic action and regarded the white limestones of Orange county, New York and of Sussex county, New Jersey as excellent examples of its efficiency. Yet it is also evident that if Prof. Rogers did little more than to state his belief, with little or no proof of it, Prof. Mather has done nothing more than to leave the question as he found it. From the time Prof. Rogers completed the geological survey in New Jersey, in 1837, up to 1854 no official work was done on the geology of the state. In 1854, however, the survey was re-organized by Dr. William Kitchell, as state geologist.

His first report appeared in 1855. In this report he speaks of the crystalline limestones as metamorphic, but he includes under this head also, gneisses and hornblende slate. He recognizes the granites as true eruptive or igneous rocks and mentions their occurring in the form of intrusive veins and dykes, and farther notes that these are found, with one exception, in the metamorphic rocks, notably in the white limestones.

In the annual report for 1855, p. 131, Dr. Kitchell again refers

to the white limestones. He now calls the rocks of the Highlands Azoic. His classification probably in an ascending series is "1st gneiss; 2d hornblende micaceous, feldspathic, and quartzose schists; 3d white crystalline limestones (saccharoidal marbles) interstratified with seams or layers of magnetic ore (magnetite) and iron pyrites."

One has rather to guess at his position than to gain a positive idea from his statements.

On pp. 138 and 139, however, he notes that when a knob or outcrop of white limestone occurs in the blue, it is always accompanied by dykes of granite and other igneous rocks. He also notes the presence of an increased number of minerals. On page 142 Dr. Kitchell writes in such a manner as to leave one in utter doubt as to his attitude on this question, unless he regards it as possible that rocks belonging to his metamorphic series might have escaped alteration and to have come down to us almost wholly unchanged while others were highly modified.

In speaking of the limestones of the southeast foot of Pochuck mountain, he says: "There are portions (i.e. of the limestone) which are but partially altered; the stone in part retaining its original color, but generally containing impurities. Other portions still are of a blue color, containing here and there a little calcite, in which there is considerable plumbago. In the parts which are but slightly altered, the texture ranges from compact to subcrystalline; and in those which are more completely changed, from sub-crystalline to that which is completely crystalline, thus passing by regular gradations from ordinary blue limestone to that which is highly metamorphic." Rogers nowhere made a stronger statement than this and yet Dr. Kitchell distinctly classifies these white limestones with the gneisses.

As was before remarked the only avenue of escape from a flat contradiction in the same report is through the avenue which was suggested, namely, considering that the blue limestones as well as the white belonged to the same metamorphic series. Dr. Cook, however, who was Dr. Kitchell's assistant, cuts off even this avenue of escape, for in his (Dr. Cook's) report for 1868 he says:—

"The true position and identity in age of the crystalline limestone and gneiss was proved by Vanuxem and Keating, in 1822, and this view has been sustained by all the observations of Dr.

Kitchell and his assistants, and can easily be verified by any one who will visit the localities cited in this report."

I offer these quotations as matters of fact rather than of criticism, for Dr. Kitchell's really valuable work was terminated by his death in 1861, and it is hardly fair to criticise adversely, a man's incomplete work.

During the year 1862, mainly through the efforts of Dr. Cook, the survey was re-organized with Dr. Cook as state geologist. In the first report of 1863 Dr. Cook states his position most unambiguously. On p. 7 of this report he says:—"I have endeavored to make plain and indeed to demonstrate a number of points which were not clearly settled in the first survey. Thus the commonly received opinion that the white limestones of Sussex are the same as the blue limestone only changed in color and structure by heat, is clearly shown to be erroneous by the sketch of a locality near Franklin Furnace, where the two rocks are shown to be totally distinct from each other, one of them being in layers which dip to the southeast while the other lies upon the upturned edges of the former and dips to the northwest."

As it is recorded the observation is faulty in the extreme. The two rocks are nowhere seen to be in contact and the blue limestone lies upon the upturned edges of the gneiss only and not near the white limestone.

North of the Furnace pond the white limestones dip S. E. The next outcrop is granite, and the next is an outcrop of blue limestone which dips N. W. and in which fossils, Obolella crassa, and graphite, were found as well as numerous oölites. This limestone is called blue or unaltered, dips N. W., and cannot therefore "lie upon the upturned edges of the white."

In the report for 1864, Dr. Cook again briefly refers to the white limestone rock "which is found interstratified with the gneiss rock, along the entire N. W. border of the Highlands of Warren and Sussex counties." In an accompanying section he shows that he considers the rock "Azoic."

In 1868 Dr. Cook published a very exhaustive report on the "Geology of New Jersey." In this report, the chapter on the Azoic Formation has a very important statement bearing on this subject, and I quote the opening paragraph of this chapter in full: "Under this division are included the gneiss rocks, the crystalline limestones and the beds of magnetic iron ore. There has been some

uncertainty in many minds in relation to the age of these rocks, it being thought by many that they were of the same age as the blue or magnesian limestones, only changed by metamorphic action, and that the passage from one to the other was a very gradual one. Prof. Rogers in his Final Report on the geology of New Jersey, pp. 61-80, under the head of "Igneous rocks connected with Formation II," discusses the changes induced upon the Blue limestones by igneous action and assumes that all the white or crystalline limestones are made from the Blue limestones by the action of heat which has been applied by the agency of dykes of granite.

In regard to the crystalline limestones he was mistaken. They are everywhere conformable to the gneiss and interstratified with it. This mistake is acknowledged by his former assistant, J. P. Lesley, in the American Journal of Science, vol. 89, p. 221. The true position and identity in age of the crystalline limestone and the gneiss, was clearly proved by Vanuxem and Keating in the "Journal of the Academy of Natural Sciences" in 1822, and this view has been sustained by all of the observations of Dr. Kitchell and his assistants, and can easily be verified by any one who will visit the localities cited in this report."

This defines the position of Dr. Cook on this question. His opinion is evidently not founded so much upon personal investigation and observation as upon the reports of others. His proof hangs upon the extremely attenuated thread of conformability, which is even in this case more apparent than real, and upon the confusion attendant upon the use of the term "gneiss." This opinion Dr. Cook held up to the day of his death. The errors of Vanuxem and Keating I have already pointed out. With regard to Prof. Lesley's acknowledgment of the error of Prof. Rogers this much only can be said: He simply announces his belief casually in reply to a criticism on Prof. Rogers' work by Hall and Logan, that Prof. Rogers was in error. His belief appears to rest upon a misunderstood statement, published in the American Journal of Science, 1861, vol. 82, p. 208, by Dr. Cook. As Prof. Lesley quotes Dr. Cook "he (Dr. Cook) has seen horizontal Potsdam sandstone or Calciferous beds overlying these upturned Franklin limestones."

In the first place, these beds are not horizontal, but dip steeply to the N. W.; In the second place, they rest upon the gneiss of Franklin furnace and are nowhere near the white limestone.

From 1868 to 1886 no special mention was made of the white limestones. The question was practically settled. In 1886 however, Dr. Britton, in his classification of the rocks of New Jersey, showed clearly that the idea of the Archæan age of these limestones had grown in strength with the lapse of years. In this report, "State Geological Survey, 1886," pp. 77 to 83, he again groups the crystalline limestones in the Archæan. His grounds for this are not new :—interstratification with gneisses and conformability.

This brings the history of the question as to the age of the white limestones of the Northwest border up to date, so far as New Jersey is concerned. It will be seen, I think without doubt, that there is absolutely no proof offered which seems to establish the opinion that these limestones are Archæan ; on the other hand, Prof. Rogers recorded enough of evidence to establish their post Archæan age, or at least to have kept the question open.

In the comments which I have made I have endeavored to point out the errors of the older writers as well as to again record their more valid observations.

THE MOVEMENT OF ICE ON MINNESOTA LAKES.

By E. H. Atwood, St. Cloud, Minn.

The present winter has been a favorable one for studying the causes of the ice movement upon the numerous lakes in Minnesota. Residents of this state are familiar with the sight of the upheavals of the ice upon our lakes, and to those dwelling in the vicinity of lakes the roaring of the ice during the changes of temperature is of so frequent occurrence that but little notice is taken of it. The absence of snow upon the ice exposes it to the weather, and as it is as sensitive to changes of temperature as a thermometer the present winter has caused an unusual movement. There are but few if any lakes in Minnesota where the conditions are so favorable for studying the ice movement in all its different relations as can be found upon Pearl lake, situated in Maine Prairie township. A recent visit to that beautiful sheet of water found the ice crowding with tremendous force upon the southern shore. Along this shore are situated numerous springs where the water oozes up through the gravelly bottom, which prevents the ice from freezing to the bottom and sides. As there are no

springs on the northern side the ice freezes firmly to the bottom and sides, consequently when the ice expands it moves in the direction of the least resistance, which in this case is to the south.

Having studied the ice movement upon this and other lakes for many years in temperatures ranging from 40° above to 40° below zero, I find that ice after it has once formed into a solid body is subject to the same law which governs other bodies; that is, that heat expands and cold contracts. The question naturally arises, if heat expands the ice in a certain direction why does it not contract to its first position when the temperature falls to its first degree of cold? The correct solution of this question will show the true principle of the glacial movement, which has been so little understood by scientific men of all ages. To explain the movement of the ice in one direction, let us begin of a bright morning with the ice on the lake, say 20 inches thick and the temperature 10° below zero. Remember that while the temperature is 10° below on the top side of the ice, the bottom lies upon the water with an unchanging temperature at or near 32° above zero. As the sun comes up and its rays strike the ice, the temperature rapidly rises, causing the surface of the ice to expand, while the temperature of the lower surface remains the same. As the lower ice cannot stretch to keep up with the expansion of the upper surface, innumerable cracks will be formed on the under surface, some reaching part way through the ice and a few clear through. These cracks are wedge-shaped, like the capital letter A. They immediately fill with water and freeze, thus forming so much new ice and preventing contraction when the temperature falls. This movement will continue as long as the temperature rises, accompanied by a roaring and cracking sound like a fierce battle, the ice meanwhile crowding upon the shore, often 12 to 15 inches a day. About 4 o'clock P. M. the temperature begins to fall and the top of the ice to contract, while the bottom remains stationary. The contraction of the top causes V-shaped cracks to form from the top downward, the new ice which had filled the A-shaped cracks in the bottom preventing the body from resuming its first position. These cracks from the top fill with water and freeze until the next morning, when we have a body of ice which has been enlarged by the action of both heat and cold, and as the morning sun shines upon its surface the same process of expansion and contraction and the formation of new ice goes on.

Pearl lake is about one and one-third miles in diameter and the ice has been known to crowd up on the shore over 40 feet in three months when clear of snow, which would average 5 to 6 inches a day. But when covered by a few inches of snow the ice will remain stationary all winter, because the snow is a non-conductor and prevents the changes of temperature from affecting the ice. Although the movements of the ice in the existing glaciers of the world have been studied by the most scientific men of the age and many theories have been advanced as to the cause, it seems plain to me that there can be but one cause, viz.: contraction by cold and expansion by heat; and the fact that ice remains inactive when so covered as not to feel the changes of temperature goes to prove that were the temperature to remain uniform for any length of time in the region of a glacier its movement would cease.

NOTES ON THE GEOLOGY OF THE SOUTHWEST.

By Robert T. Hill, Austin, Texas.

Gold in Indian Territory.—The occurrence of gold in the Indian Territory has been the cause of periodic mineral excitements for several years. The writer has had occasion during the past year to examine the regions wherein the gold occurs. There are two of these, one near Tishomingo in the Chickasaw Nation and the other in the Wichita mountains upon the Comanche Reservation. In both localities the conditions are favorable for mineral deposits, consisting of igneous contacts of granite and eruptive material with numerous veins and faults, accompanied by large deposits of debris derived from them, sufficient to warrant investigation for placer deposits, in the Tishomingo district at least.

The just rights and well founded opposition to investigation of the present Indian proprietors prevent any careful exploration, while even reconnoissance is accompanied by danger.

The mineral resources of Texas are the subject of considerable inquiry owing to recent official promulgations from the office of the state geologist concerning the occurrence of tin (cassiterite) platinum, and lengthy communications in the press of the state upon the value of the woody lignites aud Eocene greensands. While it is apparent upon the face of these announcements just at the beginning of a session of the Legislature, that their purpose is not altogether scientific, it is to be doubted if it is a wise policy

for the popular mind to be enthused with visions of mineral possibilities that do not exist, or at least have not been practicably demonstrated. The quantity of platinum found in a specimen of inexact locality was a single fragment less than a pin head—sufficient however to justify a scientific investigation. The same can be said of the tin ore, which so far as yet known exists only in quantities sufficient for mineral curiosities. The experience of hundreds in Mississippi, Alabama, Arkansas and Texas, has shown the commercial impracticability of the lignites for fuels, while the Tertiary greensands fully studied by Hilgard have never been adapted to agriculture. There are many valuable materials in Texas however for economic development. Rich chalk and Cretaceous marls and greensands, gypsum, and probable phosphate beds occur. Her vast coal fields have never been looked into by a competent expert, except in the interest of private parties. Superb building stones and structural material await development, while the conditions for manufacturing improved artificial Portland cements—such as America is now entirely dependent upon Europe for—exist in the chalk districts of Texas in marvelous quantities. In the rarer minerals, the state is exceedingly rich, but in nearly every case where investigated these have proved of little quantity, except in the Trans-Pecos region where there are undoubtedly valuable silver districts.

In the small Paleozoic area of the Burnet district from which the overlying Cretaceous beds have been eroded there is a greater diversity of rare minerals than in any spot in America, over thirty of the known chemical elements including many of the rarer elements such as yttrium, thorium, etc., having been found at a single locality (Barringer hill), by Dr. Edgar Everhart of the State University.

The iron and mangenese ores of the state are of the greatest value, and are now being rapidly developed by private capital.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Perisomic Plates of the Crinoids. By CHARLES WACHSMUTH AND FRANK SPRINGER. (Proc. Acad. Nat. Sci., Phila., 1890, with two plates.) The recent progress in crinoid morphology has been somewhat phenominal. Towards a better understanding of the phylogenetic

relationships of this attractive, yet rather anomalous, group of echinoderms paleontology has aided in no small degree. In fact it is due chiefly to a study of the fossil forms that the present advanced state of the subject has been reached. And it may be truly said, in this connection, that no group of writers has done so much in this field as the American students of ancient life who have had occasion and good fortune to labor in the paleozoic horizons of the Mississippi basin. Among these observers none have carried on such an extensive series of investigations and have obtained such marvelous results as Messrs. Charles Wachsmuth and Frank Springer, who have lately made another most valuable addition to a knowledge of the morphology of the crinoids. The results referred to are embodied in the memoir just issued, which may be well regarded as one of the most important contributions that has appeared since the days of J. S. Miller.

The presentation treats chiefly of the structure of the ventral covering in the different groups of the crinoids; of the plates between the rays; and of the relations these hold to one another and to those of the teguments. Hitherto it had been supposed by some authors that the disk, or that part enclosing the visceral cavity, was, in many, if not all, of the paleozoic crinoids covered by a second integument, which was wanting in later and recent forms. As to the plates between the rays all writers have discriminated between "calyx" and "disk" inter-radials; the former term being applied to the massive, well-formed ossicles of the paleozoic crinoids; the latter to the small irregular perisomic pieces of later species. The calyx inter-radials, except those of the Apiocrinidæ, were thought to be followed by a vault, the others by a disk. The studies of Messrs. Wachsmuth and Springer led them to suspect that these assumptions were not altogether correct; and a careful investigation seemed to indicate that all plates lying between the rays and their subdivisions are parts of the same element; and that therefore the so-called "vault," as a distinct structure, has no place in crinoid morphology. It is also shown that, in paleozoic times, the rigid integument such as is found in the later Camarata gradually became evolved from the thinly plated disk of the earlier forms and that the heavy plates between the rays are exaggerated perisomic plates. By a comparison of the various Camarata it is found that during the Silurian the ventral surface in the majority of cases was composed of small irregularly arranged pieces; that these increased in size during the Devonian; and in the Carboniferous attained great prominence and rigidity, as is best shown by the Batocrinites and Actinocrinites. All stages of transition between the two extremes are readily traced. In regard to the ambulacra observations show that these features may be tegminal or subtegminal, even among the forms of the same genus; and that they are more frequently exposed in the earlier crinoids. Among the latter the covering pieces are smaller, more regularly arranged and not so highly differentiated as in the later species. In this respect the resemblance to recent forms is very striking; and except for the sutural union of the various plates and the closure of the mouth and food-grooves the conditions of the

plates in the two groups would be nearly identical, at least in a large number of cases. From a comparison of young and adult individuals it is further assumed that in the former the ambulacra are often exposed near the margin of the tegumen while in the latter they are entirely subtegminal. Thus the tegminal ossicles encroach from each side of the ambulacra and finally close above them, crowding the ambulacral skeleton inward. The so-called radial dome plates which were always regarded as true vault structures are shown to be merely greatly modified covering pieces.

Other crinoidal groups are also taken up. In the Fistulata no vault is recognized, but all the plates between the ambulacra and between the radials are considered as perisomic. In most species the ventral sac is porous, while in others there is in front of the inflation a perforated plate like the madreporite of the urchins. The Larviformia which are now restricted to forms with the ventral surface made up of orals only, without any perisomic pieces. From these observations the authors conclude "that there is everywhere but one integument covering the body; that the ventral pavement, although undergoing various modifications in geological times, is a disk" and that all crinoids, recent and fossil, are constructed substantially on the same plan. All plates lying between the rays and also between the ambulacra are therefore to be considered as perisomic pieces.

The second part of Messrs. Wachsmuth and Springer's paper is devoted to the anal plates of crinoids; and is to a large extent a reply to Mr. F. A. Bather's recent article, in the Annals and Magazine of Natural History for April, 1890, on the origin and development of the anal plates of the Fistulata. This author regarded the Fistulata as having two distinct anal plates, the so-called "radianal" or azygous piece and the "brachianal" or special anal plate. As to the former, the authors seem to be in accordance with the view that it is the lower section of the compound right posterior radial which in some groups performed anal functions. As to the second plate the two conceptions differ very essentially. Mr. Bather appears to think that the brachianal was primitively given off from an axillary, as a plate morphological by corresponding to an ordinary brachial, and that in the course of its geological development it changed its position and passed down from above, between the radials, to the basals. This is explained by an increase in the width of the ventral tube in later forms, which caused a sinking of that organ into the dorsal cup; and by the shifting of the radianal to one side from its position beneath the radial. Messrs. Wachsmuth and Springer undertake to prove that this theory is based upon a misinterpretation of the functions of certain plates. They show that the right posterior radial of *Iocrinus*, *Heterocrinus and Hybocrinus* is no more an axillary than the radial of an *Actinocrinus*, which on its upper sloping face supports an ordinary inter-radial. They assert that there is no sinking of the anal tube, nor a shifting of the radianal, but that, in those forms in which a widening of the anal area has taken place, a new plate was introduced

between the radials, and that the radianal does not change its position, but, when present, rests within the angle of two basals, thus showing that the one is radial, the other inter-radial in position. This plate, which in *Iocrinus* lies upon the radials, and which, in *Poteriocrinus*, is said to have passed down to the basals, is a plate of the tube.

Antiquities from under Tuolumne Table mountain in California. By GEORGE F. BECKER. Bulletin, G. S. A., vol. ii, pp. 189–200, with a plate, and one figure in the text; Feb. 20, 1891. If further evidence was needed, beyond that set forth by Whitney in "The Auriferous Gravels of the Sierra Nevada of California," to prove the occurrence of human remains and stone implements in the deep placer gravels of that state, underlying basaltic lava, the demonstration is amply supplied in this paper. A mortar and pestle found by Mr. J. H. Neale, and a broken pestle found by the well known geologist, Mr. Clarence King, in the gravel under the basalt of Table mountain, Tuolumne county, are here figured; and their perfect regularity of outlines and their polished (neolithic) character seem very surprising, as showing the skill attained by man before the great extension of the Sierra Nevada glaciers, which followed the outpouring of the lavas. After the date of these implements, the gravels were covered by the lava flows, displacing the streams, which have since cut cañons 2,000 feet deep below the top of Table mountain. Mr. Becker believes that the Californian glaciation, subsequent to the basaltic lavas, was more recent than the glaciation of the northeastern states, and that certain Pliocene animals, whose remains occur in the same gravels, had survived to a late portion of the Pleistocene or Glacial period. In the same manner, the Equus fauna, formerly supposed to be Pliocene, is shown by Gilbert to have continued so late as to be contemporaneous with the second rise of lakes Bonneville and Lahontan, which was probably coincident with the latest Sierra glaciation.

Notes on the early Cretaceous of California and Oregon. By GEORGE F. BECKER. Bulletin, G. S. A., vol ii, pp. 201–208; Feb. 20, 1891. That part of the Shasta group which is extensively represented in the Coast ranges of California, containing Aucella and a few other shells, has been supposed to be older than its part which has been studied near Horsetown, in Shasta county, containing Ammonites and numerous other fossils, but not Aucella. Beds recently discovered to be fossiliferous at Riddles, Douglas county, Oregon, combine these faunas; and they are also found together by Dr. G. M. Dawson in the Queen Charlotte islands. The Shasta beds in the Coast ranges and at Horsetown are therefore probably of the same age, which appears to be the Gault. With them are also to be included the Aucella-bearing strata of the gold belt in the Sierra Nevada. The original plication and upheaval of the rocks forming that range, once thought to have occurred at the end of Jurassic time, are thus referred to the close of the Gault epoch in the Cretaceous period.

The relation of secular rock-disintegration to certain transitional crystalline schists. By RAPHAEL PUMPELLY. Bulletin, G. S. A., vol. ii, pp. 209–224, with four figures in the text; Feb. 19, 1891. Pre-Cambrian decay of the granitoid gneiss forming the nucleus of Hoosac mountain, in western Massachusetts, is shown to have led to the formation of the overlying conglomerate and gneiss, laterally continuous into quartzite in which Mr. Walcott has found Lower Cambrian trilobites. The depth of this ancient rock-decay was probably similar to that now found upon all areas of feldspathic rocks in warm and moist regions, where the surface has not been glaciated. During the folding and metamorphism of the Cambrian strata of the Hoosac and Green mountains, there has often been produced an apparent transition and conformity with the Archæan gneisses and granites. The transition zone consisted below of that part of the more or less disintegrated Archæan which escaped denudation during the subsidence of its land surface into the Cambrian sea, and above comprised the basal Cambrian conglomerates and other detrital beds formed by the erosion of the disintegrated rock. Lithologic gradation and parallelism of lamination from Cambrian to Archæan are found in this zone. Analogous observations are cited from the Adirondacks, the southern Appalachians, and Iron mountain, Missouri.

The Geotectonic and Physiographic Geology of western Arkansas. By ARTHUR WINSLOW. Bulletin, G. S. A., vol. ii, pp. 225–242, with a map, and nine figures in the text; Feb. 26, 1891. This paper gives a very interesting general description of the stratigraphy and contour of a Carboniferous area lying on both sides of the Arkansas river and extending from Ft. Smith 90 miles eastward. The greater part of the district has a nearly horizontal stratification or only gentle flexures. South of these are steep flexures, overturned folds, and faults, running from east to west, which the author ascribes to the time of the Appalachian revolution and to "a trans-Mississippian extension of the same cause." Following Reade, this cause is thought to be the rise of the isogeotherms in a mass of very thick sediments. The resulting expansion of their lower layers would find room by flexure and plication, with upheaval; and during this process superficial erosion would expose steeply inclined or compressed and inverted folds, the dips becoming steeper and the folds more appressed in proportion as the overlying weight diminished.

Report upon the United States Geographical Surveys west of the one hundredth meridian, in charge of CAPT. GEORGE M. WHEELER, under the direction of the chief of engineers, U. S. Army; vol, i, Geographical report, quarto, pp. 780. xxxviii plates and three maps; War Department, Washington, 1889.

This report, though made under date of June 1, 1879, when it was substantially completed, was not offered for publication till 1887, "from press of other duties and subsequent prolonged illness." Though it is the first in the series of seven volumes of Lieut. Wheeler's survey, it is the last to appear. Volume ii, Astronomy and Barometric Hypsometry,

was published in 1877; vol. iii, Geology, in 1875, with a "supplement" volume in 1881; vol. iv, Paleontology, in 1877; vol. v, Zoology, in 1875; vol. vi, Botany, in 1878; and vol. vii, Archeology, in 1879. It is needless to say that this series of scientific survey reports embraces a vast amount of valuable information, and of the series, vol. i stands in that respect, second to none of them.

This is strictly a geographical volume—*i. e.* it defines the outlines of the topography, and illustrates it by several lithographic plates. The several expeditions of Capt. (then lieutenant) Wheeler, from 1869 to 1879, are reported in general terms, showing that the parties engaged in them must have been very industrious to be enabled to construct the atlas sheets and to give the mass of scientific information of the country embodied in the former reports and maps of this survey. These descriptions are followed by eight appendixes which occupy pp. 229-765. These give latitude, altitude and longitude of prominent points west of the 100th meridian, description of the atlas sheets of the report, methods of survey, notes on the survey and disposal of the public lands, and some considerations upon national government land and marine surveys. Appendix F contains a very valuable feature, being a "memoir upon the voyages, discoveries, explorations and surveys to and at the west coast of North America and interior of the United States west of the Mississippi river, between 1500 and 1880, including later bibliographical and other references to determined latitudes, longitudes, and altitudes available for the basis of the permanent official topographic atlas of the United States." In this memoir are shown reproductions of some old maps of North America, beginning with that of Benincasa of the island of Antilia, in 1463. It also shows that even as late as 1722 California (*i. e.* Lower California) was considered an island in the Pacific ocean, its northern portion being called "New Albion." Following this is an epitome of the memoir prepared by Gen. G. K. Warren, of all the explorations in the western portion of the United States, in 1857. The memoir in full is found in the Pacific Railroad Reports. The volume closes with a more full description of all later explorations by the Government west of the Mississippi river between 1857 and 1880, by Capt. Wheeler, being a compend of great value for all students of the progressive discovery and development of that part of North America. The last appendix embraces an account of the survey itself, giving its organization, administration, function, history and cost.

Elements of Geology. By JOSEPH LECONTE. Revised and enlarged, with new plates and illustrations. pp. 640. (New York: D. Appleton & Co., 1891.) This third edition of a widely used text-book will be welcomed by multitudes of teachers and students. Within the eight and a half years since its previous revision, the science has made rapid progress, both in the accumulation of new observations, and in their theoretic co-ordination. Many portions of the book have received important additions or have been re-written, including those which treat of the geologic work and history of rivers; the phenomena of earthquakes;

theories of coral reefs; geologic causes of the present distribution of animals and plants; mineral veins, faults, and mountain-building; Devonian fishes, and Carboniferous conifers; the origin of birds and mammals; the Potomac, Comanche, and Laramie series; the Tertiary mammalian fauna of America; evidences of continental elevation during the Quaternary era, regarded as the probable cause of the glacial climate; the Quaternary upheaval of the Sierra Nevada and Great Basin ranges; terminal moraines and ice-dammed lakes; and the most recent discoveries of human remains and implements, both in Europe and on this continent.

A last word with the Huronian. By ALEXANDER WINCHELL. Bulletin of the Geological Society of America, vol. ii, pp. 85-124, with a map and three figures in the text; Feb. 5, 1891. Only two weeks before the death of its distinguished author, this brochure was issued; and in the March number of the GEOLOGIST (p. 199) his discussion of the progress of opinions held by American geologists concerning the Taconic and Archæan rocks was noticed. Little did Dr. Winchell expect that literally this essay would be his last utterance in the science which he had done so much to advance! He was looking forward to the preparation of an elaborate treatise on the ancient metamorphic rocks of the Northwest, toward which these recent publications were as stepping-stones. The diverse uses of the name Huronian by Murray, Logan, Hunt, Irving and others, are stated, with comparisons of the areas where rocks referred to this system are developed north of lake Huron and about lake Superior; and the author adds notes of his personal observations in the vicinity of Echo lake, 15 miles east of Sault St. Marie. It is advocated that the name Huronian be retained for the quartzites, schists, and slate conglomerate, to which it was originally applied, unless it should be superseded by Taconic as an earlier synonymous name; but that a lower series of schists, conglomerates, and slates, to which the name Huronian has been extended, be distinguished as the Kewatian system, following Lawson's classification, which is based on explorations about the Lake of the Woods.

The Nickel and Copper deposits of Sudbury district, Canada. By ROBERT BELL. With an appendix on *The silicified glass-breccia of Vermilion river, Sudbury district*, by GEORGE H. WILLIAMS. Bulletin, G. S. A., vol. ii, pp. 124-140, with four figures in the text; Feb. 5, 1891. The recently discovered ores in the region about Sudbury, a station of the Canadian Pacific railway north of lake Huron, are in all cases a mixture chalcopyrite and nickeliferous pyrrhotite. They are found upon a tract about 70 miles long from southwest to northeast, with a maximum width of about 50 miles, occurring principally along fault-planes of diorite as a matrix of igneous injection between its brecciated fragments. Nickel is confined to the pyrrhotite, in which it is usually present in the proportion of from 1 to 5 per cent. A remarkable volcanic glass-breccia of great thickness and extent, whose structure has been perfectly preserved by silicification, is closely associated with the diorite.

The Overthrust Faults of the southern Appalachians. By C. WILLARD HAYES. Bulletin, G. S. A., vol. ii, pp. 141-154, with map and sections; Feb. 9, 1891. Two thrust faults, partly coincident with planes of stratification, are traced in the moderately bent or folded strata of the great Appalachian valley in northwestern Georgia and adjacent portions of Alabama and Tennessee, receiving names from Rome and Cartersville, Georgia. The Rome fault is known to extend at least 275 miles, from Gadsden, Alabama, northeast and north into Virginia. In the vicinity of Rome the extent of its overthrust is at least 4 miles, and may be 6 or 7 miles. The Cartersville fault or thrust-plane has an inclination frequently so low as 5°, and rarely more than 25°. Its maximum horizontal displacement appears to be not less than 11 miles, equalling that of the thrust-planes studied out by Peach and Horne in the highlands of northwestern Scotland. Other overthrust faults are mentioned as mapped out by Keith a few miles northeast of Knoxville, Tennessee, and by Walcott in the Taconic region of New York. Among the conditions on which the production of thrust faults depends, the most important is shown by Mr. Hayes to be the relation of the rigidity of the strata to the superincumbent load; and he concludes that probably the strata had been folded and partially eroded before the time of their faulting. In the discussion of this paper, Prof. W. M. Davis suggests that the faults may have been of post-Triassic date, long after the Appalachian folding which took place at the close of the Carboniferous period. He would attribute the lateral compression producing these overthrusts to the same date and causes as the monoclinal tilting and faulting of the Triassic beds of Pennsylvania, New Jersey, and the Connecticut valley.

The structure of the Blue Ridge near Harper's Ferry. By H. R. GEIGER and ARTHUR KEITH. Bulletin, G. S. A., vol. ii, pp. 155–164, with map and sections; Feb. 11, 1891. Ten sections are presented, of which nine cross the Blue Ridge and South mountain within about ten miles north and south of Harper's Ferry, and one acrosses the Catoctin mountain about ten miles east of the Blue Ridge. The authors refer the sandstone here forming generally the highest part of the Blue Ridge and of the South and Catoctin mountains to the Silurian system, and they regard the structure of these ranges as synclinal, mainly in open normal folds, with the descending order of the strata as follows: the Massanutten sandstone, believed by W. B. Rogers to be the lowest of the series and to owe its position to the overturning of anticlinal folds; the Martinsburg shale; the Shenandoah limestone, known by its fossils to be of Chazy-Calciferous age; the Catoctin epidotic schist; and granite. Fossils have been found only in the limestone.

Note on the geological structure of the Selkirk range. By GEORGE M. DAWSON. Bulletin, G. S. A., pp. 165–176, with a section; Feb. 12, 1891. Seeking to connect a region which has been somewhat thoroughly studied in the interior of British Columbia, with the section surveyed by McConnell across the Rocky mountains proper, or the most

eastern ranges of the complex Cordilleran belt, Dr. Dawson has carefully examined the section along the Canadian Pacific railway in its passage through the intervening Selkirk mountains. In descending stratigraphic order, and in geographic sequence from east to west, the rocks are quartzites, argillites, limestone, and schists, provisionally regarded as Silurian and correlated with the Halysites beds and graphtolite-bearing shales of McConnell's section; gray schists, quartzites, conglomerate, and argillites, regarded as Cambro-Silurian and Cambrian, having a thickness of 25,000 feet in the Selkirk range, from which they are denominated the Selkirk series, probably equivalent to McConnell's Castle mountain group and the upper part of his Bow River series; blackish argillite schists and phyllites, with some limestone and quartzite, about 15,000 feet, named Nisconlith series in British Columbia; and gray gneissic rocks and coarse mica schists, forming the Shuswap series of the Archæan age. The Selkirk and Nisconlith series are conformable and comprise a total thickness of 40,000 feet of strata which the author refers to the Cambrian system, not finding reason for distinguishing the lower portion by the name Algonkian adopted by Wallcott. Formations above the Silurian, ranging from the Devonian to the Cretaceous, which enter into the composition of the neighboring parts of the Rocky mountains, are nowhere seen in this section of the Selkirks.

Graphic field notes for areal geology. By BAILEY WILLIS. Bulletin, G. S. A., vol. ii, pp. 177–188, with one plate; Feb. 12, 1891. Methods of field observation and record employed by the U. S. Geological Survey in the Appalachian mountain region are here described. Plats sufficiently accurate to be used in preparing maps for publication are made on pages of the note-book, from measurements of distances by pacing, with determination of bearings by a hand compass; but when it can be conveniently carried, a traverse plane-table is used, the plats being then on sheets of drawing paper. These graphic methods are found to be far more serviceable than verbal notes for the greater part of the information to be recorded, and they tend to make keen observers.

Annual Report of the Geological Survey of Arkansas, for 1889. JOHN C. BRANNER, *State Geologist, vol. ii. The Geology of Crowley's Ridge,* By R. ELLSWORTH CALL, Little Rock, 1891, pp. 283. Eleven plates and a geological map of the western portion of St. Francis county, and a map of Crowley's ridge showing the flooded plains of adjacent streams.

The description of the sections and of the topography and local geology of the ridge is by Prof. Call, who also has "notes on the trees of the ridge" and a description of a new pelecypod mollusk from the Tertiary (Mytilus hamatoides).

Prof. R. D. Salisbury contributes a chapter on "the relationship of the Pleistocene to the Pre-pleistocene formations of Crowley's ridge and adjacent areas south of the limit of glaciation;" and F. H. Knowlton describes "unfortunately" (as he says) four new species of fossil wood found by Prof. Call in his exploration of the region.

The chief general interest of the volume centers in Prof. Salisbury's discussion of the age of the strata of the ridge. The ridge itself is one of those remnants from erosion left by the Mississippi river which are found frequently along the course of the valley in its non-glaciated portions. It extends from near Cape Girardeau, in Missouri, to Helena, in Arkansas, making, in its central portions, a broadly crescentic bend toward the west.

Prof. Salisbury regards the superficial loess and loam mantle of the ridge as referable clearly to the Pleistocene, "and under the Pleistocene to the first glacial epoch," and he is of the opinion that the second glacial epoch has no representative in the ridge. The river-terraces that characterize that epoch by heading in its terminal moraines pass below the alluvium of the Mississippi before reaching the latitude of Crowley's ridge. The most southern point at which such have been recognized in the Mississippi valley, being a short distance above Cape Girardeau, where a remnant exists in a tributary valley.

The gravels and sands of Crowley's ridge are unconformable below the loess, and are frequently separated from the loess by a layer that exhibits a characteristic humus, showing the interposition of an epoch of subaerial exposure. This humus bed he considers the dividing line between the Pleistocene and Pre-pleistocene. The gravel and sand of the body of the ridge therefore he regards as not of glacial origin—and this conclusion he extends to large areas in western Tennessee and Kentucky and in southern Illinois, and in eastern Missouri where such gravels and sands extend, and where they have sometimes been reported as of glacial origin. This important conclusion is well sustained by the handling of the facts and can hardly be questioned. The paper points to a delimitation of the Pleistocene from any underlying older but similar formation, and mentions the characters by which the distinction may be made by any geologist, and therein it adds an important advance step to our knowledge of the Pleistocene.

LIST OF RECENT PUBLICATIONS.

1. *State and Government Reports.*

Bulletin No. 2, Geol. Surv. of Mo. A Bibliography of the geology of Missouri. F. A. Samson.

Bulletin No. 3, Geol. Surv. of Missouri. The clay, stone, lime and sand industries of St. Louis city and county, G. E. Ladd; The mineral waters of Henry, St. Clair, Johnson, and Benton counties, A. E. Woodward.

Bulletin No. 4, Geol. Surv. of Missouri. A Description of some Lower Carboniferous crinoids from Missouri, S. A. Miller.

Report on the Cahaba coal fields, Joseph Squire; Geology of the valley regions adjacent to the Cahaba field, E. A. Smith; Geol. Surv. of Alabama. 31 Figs., 7 plates and large map.

2. *Proceedings of Scientific Societies.*

Proceed. Phil. Acad. Nat. Sci. Part III. Oct.-Dec., 1890, contains: The Perisomic Plates of the Crinoids, Wachsmuth and Springer (Reviewed in the GEOLOGIST Vol. VII p. 255); The Eocene mollusca of the state of Texas, Angelo Heilprin; The geology and paleontology of the Cretaceous deposits of Mexico, Angelo Heilprin; Geology of the South (Chester) Valley Hill, Theo. D. Rand; Geology of Artesian Wells, Atlantic City, N. J., Lewis Woolman.

Proceed. Rochester Acad. Sci., Vol. I. pp. 1 to 100, Description of new Meteorites, E. D. Howell.

Transactions Meriden Sci. Ass., Vol. IV, 1889–1890 contains; Some geological features of Meriden, J. H. Chapin; Cycadinocarpus Chapinii, J. H. Chapin.

Journal Cin. Soc. Nat. Hist., Jan. 1891 contains: New and little known American Ostracoda, E. O. Ulrich; The Genus Sphenophyllum, J. S. Newberry.

3. *Papers in Scientific Journals.*

Am. Jour. Sci. *Jan. No.* Deformation of the Algonquin beach and birth of lake Huron, J. W. Spencer; Clinton oölitic iron ores, Aug. F. Foerste; Review of the Quaternary era, with special reference to the deposits of flooded rivers, Warren Upham; Some remarkably developed calcite crystals, L. V. Pirsson; Horned artiodactyle from the Miocene, O. C. Marsh. *Feb. No.* Columbite and tantalite from the Black hills of S. Dakota, W. P. Headden; Notes on the geology of the Florida phosphate deposits, N. H. Darton; Record of a deep well at lake Worth, southern Florida, N. H. Darton; Chemical composition of auricalcite, S. L. Penfield; Attempt to harmonize some apparently conflicting views of lake Superior stratigraphy, C. R. Van Hise; Powellite—calcium molybdate, a new mineral species, W. H. Melville; Gigantic Ceratopsidæ or horned dinosaurs of North America, O. C. Marsh, *March No.* Gold colored allotrophic silver, M. Carey Lea; The flora of the Great Falls coal field, Montana, J. S. Newberry; High-level shores in the region of the Great Lakes, and their deformation, J. W. Spencer; Notes on ferro-goslarite, a new variety of zinc-sulphate, H. A. Wheeler; Composition of pollucite and its occurence at Hebron, Maine, H. L. Wells; The fire-bale in Raphael's Madonna di Foligno, H. A. Newton.

School of Mines Quarterly, *Jan*, 1891, contains: The Treatment of copper slates at Mansfeldt, T. Egleston; Examination of Mines, H. S. Munroe; Notes on the Coal-Fields of Montana, W. H. Weed; Methods or Modern Petrography, H. Hensoldt; The Operations of the U. S. Geological Survey, H. M. Wilson.

4. *Excerpts and Individual Publications.*

The lake Michigan glacier and glacial channels across the Chicago divide, by Ossian Guthrie. Geol. Society of Chicago. Oct. 30, 1890.

On certain magnetic rocks of Arizona and California, Henry G. Hanks. San Francisco Microscopical Society. Nov. 19, 1890.

5 Foreign Publications.

Mittheil. Kœnig. Miner-geol. u. præhist. Mus. in Dresden, 1890. Contains: Ueber einige Lycopodiaceen aus der Steinkohlenformation; Die Graptolithen des K. mineralogischen Museums in Dresden; drei Tafeln. H. B. Geinitz.

Contributions to a catalogue of reports and papers on the anthropology, ethnology, and geological history of the Australian and Tasmanian aborigines. Part I. R. Etheridge Jr. Mem. Geol. Sur. New South Wales. Paleontology, No. 8. quarto, pp. 31. Sidney. 1890.

Nachträgliche Mittheitungen über die rothen und banten Mergel der oberen Dyas bei Manchester. Dr. H. B. Geinitz. Isis in Dresden. 1889. III. S. 48.

Ueber einige Eruptivgesteine in der Provinz Sao Pâulo in Brasilien. H. B. Geinitz. Isis in Dresden. 1889.

Verhand. d. Ges. f. Erdkunde zu Berlin. Band xvii. No. 8 u. 9, contains: Ueber die Geographie des Tana-Gebietes, Dr. Karl Peters; Ueber seine Durchquerung Grönlands, Dr. Frid. Nansen. Band xviii; Reisen in den Kordilleren der argentinischen Republik, Dr. Lud. Brackebusch; Ueber das nördliche Deutch-Ostafrika. Dr. O. Baumann.

Zeit d. Ges. f. Erd. Berlin, Bd. 25, v Heft, 1890, contains: Bericht über eine Reise durch Nord-und Mittel-Griechenland, Dr. Alf. Phillipson. Band 25. No. 1, 1891. Das Pandschab, Dr. E. Jung; Besuch des Kinkoni-Gebietes in West Madagaskar, Dr. A. Voeltzkow.

Mittheil. aus d. mineral. Institut Univ. Kiel. Bd. I. H. 3, contains; Ueber zwei Brachyuren aus dem mitteloligocæn Septarienthon Norddeutschlands, E. Stolly; Zur Diluvialfrage, F. M. Stapff. Ein Ausflug in's Erzgebirge, E. Danzie.

Verhand. d. nat. hist. Ver. (Bertkau), Bonn. 1889, zweite Hälfte, contains: Ueber die Verwandschaft der syrischen Fischschichten mit denen der oberen Kreide Westfalens, W. von Marck; Heinrich von Dechen Ein lebensbild (porträt), H. Laspeyres.—1890, erste H., Ueber die Goldfelden Südafrikas, A. Schenck; Die palæozoischen Versteinerungen der neusibirischen Insel Kotelny, E. v. Toll Rauff.

CORRESPONDENCE.

PROF. W. M. DAVIS ON THE IROQUOIS BEACH.—I will again call Prof. Davis' attention to the Algonquin beach. The map of it appears in the Jan. No. of the Am. Jour. Sc. It does not embrace the waters of the Erie Basin, nor approach the Maumee-Wabash passage. In reply to Prof. Davis' considerations;

1. *The close correspondence of the Iroquois Shore lines with the Mohawk valley:* I include in the Iroqouis beach a series of beachlets having a vertical range of 25 feet, and towards the northeast of considerably

more. Only the waters corresponding to the upper part of the series had egress by the Mohawk valley. The lower waters had to find an outlet by some other channel. The Mohawk outlet did not accomplish all that was needed, if it were the sole outlet of Iroquois water.

2. *A demand for corresponding shore lines on the outlet side of the Mohawk valley:* As already clearly shown, beaches are often wanting. But the failure in recording them is no proof, for the region has not been sufficiently explored. The warping and erosion have so deformed the broken shore lines that the casual observer may not identify them.

3. *The former expanded condition of the Mohawk river:* This is favorable to my hypothesis, but as the outlet of the Iroquois water, only the depth of a few feet above its floor corresponds to the upper stages of the Iroquois beach. Hence the objection is not well taken.

4. *The correspondence of deserted shore lines with other outlets:* The higher beaches enclosed bodies which had more than one outlet; and as we rise still higher, such bodies of water had egress by many outlets which it seems to me were straits.

Can any one comprehend a river as large as the St. Lawrence flowing through an ice dam, from a lake held above sea by a glacier, after the waters had fallen just below the level of the Mohawk valley, without dissolving away the barrier? J. W. SPENCER.

Feb. 7th, 1891.

THE INTERNATIONAL CONGRESS OF GEOLOGISTS. The usual circulars have been sent to all geological societies and prominent geologists in this and in foreign countries. It may happen that in spite of our endeavors to reach all who are interested in the labors of the Congress, some circulars may not have reached the persons to whom they were addressed, or some names may have been inadvertently omitted from our lists that should have been included. May I request that you will kindly inform your readers that, if any geologist who may be desirous of taking part in the Congress or of receiving its publications, which will probably include many valuable geological papers, will send his name to the Secretary (1330 "F" street, Washington, D. C.) it will be put upon the list and he will receive the invitation to become a member of the Congress. The small fee for membership is for this Congress only, and intended to defray the cost of printing and other necessary expenses. It is customary for geologists of the country where the Congress is held to subscribe even if they cannot be present at the Congress.

S. F. EMMONS, Sec'y and Act'g Treas.

Washington, D. C., Feb. 25, 1891.

IMPORTANT RESULTS OF THE TEXAS SURVEY: A few notes in regard to the results of this survey during the past year may be of interest.

In the eastern part of the state some thorough work has been done in mapping and studying the deposits of iron ores and the accompanying Tertiary and Quaternary strata. The results give much light on the historical geology of these periods and develop the economic fact that

we have more than one thousand square miles of iron ore deposits in this area.

The investigations in regard to the uses of lignite show that the deposits of east Texas are of better quality than those now in use in Europe for most purposes for which bituminous coals are used, and the possibility of their use for fuel, for the smelting of the iron ores and other industrial purposes.

In north Texas the results of Prof. Cummins' work have proven very important. The much discussed question of Permian-Triassic has probably been fully explained by the discovery that we have in Texas, resting directly upon the Carboniferous, a series of Permian rocks, which in the upper members carry great beds of gypsum, and that only these upper members extend north of the Wichita mountains in the Indian Territory; that in Texas the conglomerate corresponding to the Shinarump of the West is found overlying these Upper Permian beds unconformably; and that the Red Beds above this correspond to the Red Beds of the West and are entirely distinct from those below that horizon. The proof here is quite conclusive, as we have not only direct stratigraphic, but also the very best paleontologic evidence of the age of all these beds.

Along the eastern edge of the Staked Plains, north of the Brazos river, the Triassic strata are overlaid conformably by beds of Tertiary age.

In central Texas, Dr. Comstock, by his second year's field work, fully confirms and extends the results of last year as already published. On December 3d, 1890, we announced the finding of cassiterite in this region by Dr. Comstock. Its mode of occurrence has been very accurately ascertained and it is reasonable to expect its discovery at any point where certain Burnetan rocks are exposed, over a belt extending from near Burnet to near Mason. Our samples have come from eastern Llano county, and eastern Mason county, and are invariably from quartz of the oldest Archæan (Burnetan) system, as defined in the first annual report of this survey.

We have not yet discovered deposits of known workable extent and the announcement was made for the purpose of encouraging the necessary prospecting to fully determine the value of the deposits.

Large amounts of minerals containing some of the rarer elements have been found in this region; enough for commercial purposes as soon as any economic use is found for them.

In western Texas a detailed study has been made by Prof. Streeruwitz of the geology of a portion of El Paso county, including the Quitman, Sierra Blanca, and other mountain ranges. Very much has been done toward a clearer understanding of the structure and stratigraphic relations of the various granites, porphyries, quartzites, marbles, etc.

In the Cretaceous of this region, the section develops facts of such scientific importance as the absence of the alternating beds, and a much greater development of the beds of the Washita division than has hitherto been given the entire Cretaceous of central Texas.

In economic results the existence of extensive deposits of free gold and of gold and silver-bearing lead, copper and zinc ores has been fully demonstrated. As in the central district, deposits of minerals containing the rare metals are abundant and many new minerals are under examination.

On the 13th of January, we announced the finding of platinum and tin by Prof. W. H. Streeruwitz, in the Quitman mountains, El Paso county, and while it is not possible, at this time, to make a positive statement regarding the quantity in which these metals are likely to be found in this district, the fact that their presence has been thus definitely determined should prove an additional incentive to active prospecting in this region, concerning which we have already made such strong statements in the publications of the survey.

The second annual report is now in the hands of the printer and it will be issued at an early date. Yours very truly,

E. T. DUMBLE, State Geologist.

Austin, March 5th, 1891.

PERSONAL AND SCIENTIFIC NEWS.

THE LEGISLATURE OF THE STATE OF ALABAMA has placed the appropriation for the Geological Survey at $7,500 a year, and made it continuous, i. e. till otherwise provided by act of the General Assembly. This puts the survey on a very desirable footing as to permanence. The printing, engraving and all publication come out of another fund, the above-named appropriation being for salaries, and field and office work and general expenses. Prof. Smith proceeds at once to the more detailed examination and mapping of the Warrior and Coosa coal fields.

GOVERNOR JAMES P. EAGLE, OF ARKANSAS, sketches the important features of the work done by the Geological Survey, and also enumerates that which remains yet to be done. The annual appropriation has been 5,000 dollars per year. He thinks that sum is too small and instances Texas which appropriates 35,000 dollars per year for field work, Alabama which has given $5,000 per year since 1882, Illinois which expended $139,700 in four years, Indiana which has annually paid $5,000 since 1869, the Iowa survey which had $6,500 annually, Michigan, which spent $91,000 in four years, Wisconsin $149,000 in six years, Ohio which spent $7,788 a year in field and office work, Pennsylvania which has spent nearly a million and a quarter in eleven years, and New York which has spent nearly two millions of dollars on its geological survey. These figures show that the Arkansas survey, in the judgment of Gov. Eagle, has been conducted economically. "When we compare the expense of the survey with the

work accomplished and the results that must eventually flow from it, I feel that there has been no wiser action of the Legislature, of late years, than the inauguration of this important piece of work, and I feel warranted in urging that it be finished in a proper manner, especially as it is now so nearly done."

PROF. CRAGIN IS ENGAGED IN THE PREPARATION of an illustrated work on the geology of Kansas. It will comprise a stratigraphic and general section, a section on economic geology, and one on physical geography, in the first of which palæontology will be made prominent. It will include, as special features, a geological gazatteer of Kansas and list of elevations, much fuller than that of Kansas in Macfarlane's Geological Railway Guide, a catalogue of Kansas fossils, and a bibliography of Kansas geology. The section on physical geography will include faunal and floral lists (including invertebrates and cryptogams), and a chapter on the climate of Kansas, the latter written especially for the work by Sergt. T. B. Jennings of the Kansas weather service. The work will probably be issued early in 1892.

THE BACKBONE OF THE CONTINENT within the boundary of the United States, or the watershed between the Interior and the Pacific (approximately 1,850 miles long), consists of a number of distinct ranges separated by noticeable passes easily approached from the eastward or westward, and to which the appellation "Rocky mountains" has been given. This name fades away as the true condition of its topography becomes known from actual surveys, and each of the several ranges claims a title. *Geo. M. Wheeler.*

BIENNIAL REPORT OF THE MISSOURI SURVEY is an administrative report of 53 pages, in which is included a short historical sketch of past geological work in the state, a description of the progress of the work of this survey and a statement of the plans for the future; it will prove of value for purposes of reference.

THE GEOLOGICAL SURVEY OF MISSOURI, under the management of Prof. Arthur Winslow has made rapid and substantial progress, and it promises to be one of the most important and successful of the state surveys. It has issued, within the past year four valuable bulletins viz.: *Bul. No. 1* containing, besides the administrative report of the state geologist, reports on the coal beds of Lafayette county, building-stones and clays, and mineral waters, and a preliminary catalogue of the fossils occurring in Missouri. *Bul. No. 2.* A bibliography of the Geology of Missouri. *Bul. No. 3.* Clay, stone, lime and sand industries of St. Louis; The mineral waters of Henry, St. Clair, Johnson and Benton counties. *Bul. No. 4.* A description of some Lower Carboniferous crinoids from Missouri.

The state Legislature is now considering favorably a proposed enlargement of the appropriation for its maintenance, the sum named being $40,000 per year; this being double the original ap-

propriation. With the facilities which this will afford the survey will attain a degree of efficiency which cannot fail to bring great and lasting benefits to the state. We fear, however, the survey may encounter the stumbling-block which so many others have found fatal. From such large annual appropriations there have come generally revulsions which have swept away not only the present and future but all the accumulated past results. A moderate or even a small annual fund is in the end productive of larger and more substantial results than the large appropriations which come from spasmodic efforts, and are apt to cease before their plans are wrought out to completion.

THE GOVERNMENT INVESTIGATION OF ARTESIAN CONDITIONS between the 97th meridian and the Rocky mountains—Senate Document No. 222, containing the Report of the Preliminary Reconnoissance of the Artesian Investigation—has just been published. The volume contains 382 octavo pages with numerous maps, plates, and pictures illustrating the geology and occurrence of artesian water.

The reports of the numerous geologists, engineers and field agents contain a mass of information upon the subject treated such as has never before been presented in this country, and of such a nature as to render the report one of the most practical and valuable contributions to North American scientific literature. How such an immense amount of data could have been collected in a period of a few months can only be explained by the fact that Col. Rich. T. Hinton, the special agent in charge, has displayed rare administrative ability, for utilizing and collecting the knowledge already possessed by our western geologists, as well as pushing investigation with great rapidity and good taste.

PROF. DAVID S. JORDAN, PRESIDENT OF THE INDIANA STATE UNIVERSITY, has accepted the presidency of the Leland Stanford university of California. It is a pleasure to record the growing preference of the higher institutions of learning for science-bred men for their chief administrators. It is to be hoped that Indiana State university will not now fall from the ranks, but will be able to fill president Jordan's place with some other scientist. The appointment of Pres. Jordan will result in the building up of a great institution on the Pacific coast in which there will be no cramped opportunities for the scientific men who may be chosen as his colleagues and aids.

MR. R. D. OLDHAM DISCUSSES (in the Geol. Mag. for January) the origin of the Himalayas, showing that the range did not exist in pre-Tertiary times and has been developed from S. E. to N. W. The area of elevation forming this now loftiest range on earth, coexisted with an area of depression to the south of it and these two have become more and more marked as Tertiary time has gone by. "In Eocene time the N. W. Himalayas did not exist. In Sewalik-Pliocene times there was a mountain range whose hydrography

agreed with that of the present day in its main features, but must have been comparable in elevation and extent to the present Himalayas."

AMONG THE REVIEWS WE FIND A SEVERE CRITICISM of Mr. Miller's recent articles in the AMERICAN GEOLOGIST on N. American crinoids. After making a considerable extract introduced by some sarcastic remarks, the author concludes thus:

"For the rest of this amusing and exciting article we will refer our readers to the article where they will find a lucidity of exposition, an accuracy of argument and a courtesy in debate that remind one of the Society upon the Stanislaus." "The journals in which we publish may be 'conduits of ignorance and conceit,' we are 'illiterate,' 'reckless of symmetry,' 'shallow pretenders,' 'venting stupid hypotheses,' in our 'unenlightened affectation.' We make our 'usually poor English more incomprehensible' by 'snatches from German authors' and yet 'overgrown with ignorance, assumption and conceit' as we are, we humbly confess that on this side of the Atlantic we have never produced anything that would, for sweet reasonableness and smoothness of persuasion, stand a moment's comparison with the gentlemanly polemics of Mr. S. A. Miller, of Cincinnati, O."

ORIGIN OF THE WORD BRONZE. From an examination of texts due to the Greek alchemists, extracted from a document of the 16th century, Mr. Berthelot came to the conclusion, especially after comparing them with certain passages in Pliny the elder, that the name of bronze was derived from the city of Brundusium, the seat of certain manufactures in which this alloy was employed. Now, Mr. Berthelot has found a text that is more ancient by three centuries (for it dates back to the time of Charlemagne), and the indications of which are still more decisive. It is a question of a manuscript found in the library of the chapter of the Canons of Luynes, and reproduced by Maratori in his *Antiquitates Italiæ*. In the Latin text it is expressly specified as "Composition of Brindisi:" Copper two part, lead one part, tin one part—a traditional formula that has come down to our time. It would, then, seem indeed as if the word bronze was derived from the city of Brindisi, where bronze was manufactured on a large scale.—*La Genie Civil.*

ALUMINUM AT $1.25 PER POUND is in the market. A price list sent out to the trade by the Cowles Electric Smelting and Aluminum Co., of Lockport, N. Y., gives the following figures: In lots of more than 2,000 lbs., $1.25 per lb., less 20 per cent. discount, and in 1,500 lb., 1,000 lb. and 500 lb. lots, $1.25 per lb., with 15, 10, and 5 per cent. discount. In 50 to 500 lbs. the price is $1.25 net; 10 to 50 lbs., $1.50; and less than 10 lbs., $1.75 per pound.

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A CHART OF THE RUGOSE CORALS.

WILL H. SHERZER, Ann Arbor, Mich.

For the student who endeavors to acquire anything more than a superficial knowledge of a few of the more common genera of Palæozoic corals, there await disappointment, discouragement and not infrequently entire disgust. Well equipped with specimens though he may be, he is of necessity dependent upon the literature for description and classification. What with incompleteness, inaccuracies, contradictions and synonymy this literature often proves more puzzling than the fossils themselves, and may lead to its abandonment for more inviting fields of labor. We will suppose that our student has mastered, as he imagines, the generic characteristics of *Amplexus*, *Zaphrentis* and *Cyathophyllum*, and finds in his hands for study specimens of our well known *Streptelasma corniculum*. He examines them externally, appreciates the appropriateness of the specific name, notices the heavy epitheca, the pinnate arrangement of the costæ and the characters of the calyx. He next makes cross and longitudinal sections and observes the character of the tabulæ, the absence of dissepiments and the peculiar central core. He desires now to know just how the genus is to be distinguished from all others, and naturally hunts up the original description. A form like *Cyathophyllum* but distinguished by the spiral twisting together of the septa at the center. In an evil moment, however, for his peace of mind, he learns that there is not entire agreement among palæontologists in regard to the

characteristics of the genus or its being a genus at all. He finds that it is simply a form of *Petraia*, the peculiarity of which is stated to be the *absence of tabulæ* and dissepiments. Re-examining his sections he is certain that tabulæ are present. He next finds that it is properly separated as a genus, but that the distinguishing characteristic is the *absence of epitheca.* Can it be that he has been mistaken in supposing this to be present? No, a reference to his specimens again convinces him that his former observations were correct. Puzzled but persevering he learns next that the *absence of dissepiments* is the one feature by which it must be separated from all other genera. He recalls some of the species of *Amplexus* and *Zaphrentis.* The next reference volume he opens he confidently expects to find *absence of wall* or *septa* affirmed to be the distinguishing characteristic, but the genus is simply made a sub-genus of *Zaphrentis* or referred to *Ptychophyllum.* One very common Silurian coral has been assigned no less than *twenty-six* different names, and others have nearly as long a list of *aliases.*

This unfortunate condition of affairs seems to have arisen from the fact that many descriptions have been based entirely upon external characters or upon a limited number of poorly preserved fossils. Too many genera and species have been founded through ig'norance of or ignor'ance of the publications of others. A degree of satisfaction may be obtained only by collecting the literature of each genus and making a comparative study of this in connection with the fossils themselves. The value of one's conclusions will then depend upon the number and character of his specimens and the accuracy of his observations.

Another source of embarrassment to the student is the apparent blending of the genera in many instances. He will find specimens of *Cystiphyllum* in which the tabulæ and septa have reached no inconsiderable degree of development, and specimens of *Heliophyllum* in which the carinæ are almost or entirely wanting. However, if the commonly accepted theories for the creation of genera and species be true, the surprise would be the greater if these intermediate forms were not to be found. Let the student early learn the meaning of "type classification" and appreciate the fact that the limits of genera are drawn by man and not by nature. He must also bear in mind that our Palæozoic corals are

classified entirely with respect to their skeletal remains, without any regard for the yet unknown affinities of the polyps which secreted them. Modern deep-sea corals occur, belonging to the same species and growing within a few feet of each other, which if classified with respect to their hard parts alone, would probably be placed in separate genera. On the other hand we know that amongst the more highly organized forms of life differences, detected only with difficulty, characterize the skeletons of animals belonging to separate families. We fancy that if the Trumpet of the Resurrection reanimates the dusty fossils on the shelves of our museum cases there is surprise in store for many a polyp when he first gazes into the countenance of his supposed brother.

This chart of the Rugosa was primarily prepared for the purpose of making a comparative study of its genera. Reference has been made to all available literature and figures, and many specimens have been examined. An attempt has just been made to have it as accurate and complete as possible by sending out several dozen advance copies to palæontologists of Europe and America, with a request for additions and corrections. In this attempt we have been partially successful, and it is now published with the hope that it may prove of service in the laboratory for the determination and separation of genera. It is designed to contain not simply the corals which the latest investigations would place in the list, but those which the student now finds referred to it, and about which he may desire ready information. Zittel's simplification of the elaborate classification of Dybowski has been followed as best suited to our purpose, and disturbed only by the introduction of a few new genera. It is evident from the internal structure that some of the genera are out of place.

In his latest Manual of Palæontology, Prof. H. A. Nicholson considers the group simply a Section of *Madreporaria* instead of a Sub-Order of *Zoantharia* as established by Edwards and Haime. He locates and divides the group as below :

Order. **Zoantharia.**

Sub-Order A. Actinaria.
Sub-Order B. Antipatharia.
Sub-Order C. Madreporaria.
Sec. I. M. Aporosa.
Sec. II. M. Rugosa.

Sec. 1. Cyathophylloidea.
 Fam. 1. Cyathophyllidæ.
 Fam. 2. Heliophyllidæ.
 Fam. 3. Clisiophyllidæ.
Sec. 2. Zaphrentoidea.
 Fam. 1. Zaphrentidæ.
 Fam. 2. Hadrophyllidæ.
 Fam. 3. Streptelasmidæ.
Sec 3. Cystiphylloidea.
 Fam. 1. Cystiphyllidæ.
 Fam. 2. Calceolidæ.
Sec. III. M. Fungida.
Sec. IV. M. Perforata.

The group is much restricted by the removal of *Stauria*, *Cyathoxonia* and other genera to the Aporosa.

The genera printed in small capitals are the more common and important of the Rugosa.

Geological Laboratory, Univ. of Michigan. *August, 1890.*

ZOANTHARIA RUGOSA, E. AND H.

TETRACORALLA, HAECK.

Corallites simple or compound, free or grown together. Four systems of septa which have a bilaterally symmetrical arrangement and generally extend feather-like from a principal septum and two side septa, or are arranged regularly radiate. One or all of the four primary septa are distinguished either by especial size and strength or by imperfect development; in the last case being situated in the septal foveæ. The septa when alternating in the calyx are generally arranged so that a shorter incomplete one (second order) is next to a longer (first order). The visceral cavity is frequently supplied with tabulæ and dissepiments. Cœnenchyma wanting. Calyces of the compound stems clearly separated. Increase is by ova, calicinal and lateral gemmation.

Occasionally calcareous opercula occur which articulate with the counter septum.

Fam. I. INEXPLETA, Dyb.

Interseptal spaces empty (occasionally near the base slightly developed dissepiments occur). Tabulæ and cellular tissue wanting. Septa well developed.

Tribe 1. *Cyathaxoninæ*, E. and H.

Corallum top or horn-shaped, always simple. Septa in the calyx regularly radiate, well developed.

Tribe 2. *Petrainæ*, Dyb.

Calyx much deepened. The septa begin close to the outer edge of the calyx as slightly raised bands and in their downward course become complete only in the depth of the calyx.

Tribe 3. *Palæocyclinæ*, Dyb.

Corallum simple, free, disc-like or bowl-shaped. Septa well developed.

Fam. II. EXPLETA, Dyb.

"Filling-tissue" (tabulæ, dissepiments, or both) occupy the entire space of the visceral cavity.

Sub-Fam. 1. *Diaphragmatophora*, Dyb.

Tabulæ completely formed; dissepiments wanting or quite poorly developed. Septa in the calyx regularly radiate.

Sub-Fam. 2. *Plenophora*, Dyb.

Tabulæ incompletely formed, present only in the central part of the visceral cavity. Vesicular tissue in the peripheral portion.

Sub-Fam. 3. *Cystophora*, Dyb.

Tabulæ wanting, vesicular structure filling the entire visceral cavity.

Tribe 1. *Cystiphyllinæ*, E. and H.

The vesicles arranged in vertical, contiguous layers, radial to the center. In the calyx the uppermost rows of vesicles project with their arches and form endothecal bands.

Tribe 2. *Plasmophyllinæ*, Dyb.

Septa more or less developed or dwarfed. Visceral cavity filled with cellular structure.

Tribe 3. *Fletcherinæ*, Zitt.

Septa dwarfed. Vesicular tissue in the visceral cavity very coarse.

Tribe 4. *Goniophyllinæ*, Dyb.

Calyx very deep. Septa at times weakly developed. Vesicular structure in the interseptal spaces very dense. Calcareous opercula always present.

			GENUS.	FOUNDER.	TYPE.	GROWTH.
FAM. I.' INEXPLETA.	TRIBE 1.	1.	CYATHAXONIA.	Michelin, 1846.	C. CORNU.	Simple.
		2.	Duncanella.	Nicholson, 1874.	D. BOREALIS.	Simple.
		3.	Duncania.	De Koninck, 1872.		Simple.
	TRIBE 2.	4.	Cenophyllum. (Kenophyllum.)	Dybowski, 1873.	K. SUBCYLINDRICUM.	Simple.
		5.	Guynia.	Duncan.		
		6.	Haplophyllia.	Pourtalès, 1868.	H. PARADOXA.	Simple.
		7.	PETRAIA.	Münster, 1839.	P. DECUSSATA.	Simple.
		8.	Polycœlia.	King, 1849.	P. (TURBINOLIA) DONATIANA.	Simple.
		9.	Turbinolopsis. (Trochopsis, Ehren.)	Lamouroux, 1821.		Simple.
	TRIBE 3.	10.	Acanthocyclus.	Dybowski, 1873.	A. (PALÆOCYCLUS) FLETCHERI, E. & H.	Simple.
		11.	BARYPHYLLUM.	Edwards and Haime, 1850.	B. VERNEUILANUM.	Simple.
		12.	Combophyllum.	Edwards and Haime, 1850.	C. OSISMORUM.	Simple.
		13.	Hadrophyllum.	Edwards and Haime, 1850.	H. ORBIGNYI.	Simple.
		14.	Microcyclus.	Meek and Worthen, 1868.	M. DISCUS.	Simple.
		15.	* Palæocyclus.	Edwards and Haime, 1849.	P. (MADREPORA) PORPITA, LINNE.	Simple.
FAM. II. EXPLETA.	SUB-FAM. I. Diaphragmatophora.	16.	** Acanthodes.	Dybowski, 1873.	A. CYLINDRICUS.	Simple or aggregate.
		17.	AMPLEXUS. (Cyathopsis D'Orb.)	Sowerby, 1814.	A. CORALLOIDES.	Simple.
		18.	Anisophyllum.	Edwards and Haime, 1850.	A. AGASSIZI.	Simple.
		19.	Calophyllum.	Dana, 1846.		Simple or aggregate.
		20.	CHONOPHYLLUM.	Edwards and Haime. 1850.	C. (CYATHOPHYLLUM) PERFOLIATUM, GOLDF.	Simple or loosely compound.
		21.	Coleophyllum.	Hall, 1883.	C. ROMINGERI.	Simple.
		22.	COLUMNARIA. (Favistella, Hall.)	Goldfuss, 1826.	C. ALVEOLATA.	Astræiform or fasciculate.
		23.	Cyathophylloides.	Dybowski, 1873.	C. KASSARIENSIS.	Simple, astræiform or fasciculate.
		24.	† Darwinia.	Dybowski, 1873.	D. SPECIOSA.	Compound.

* Cyclolites, (pars) Lam.; Fungia, (pars) Lam.; Porpites, (pars) Schloth.
** Name preoccupied by Agassiz for a fish.
† Nme preoccupied by Bate for a crustacean.

	INCREASE.	FORM.	WALLS.	EPITHECA.	COSTÆ.	CALYX.
	Ova.	Conical.	One.	Complete.	Distinct.	Deep, with strong projection.
	Ova.	Conical.	One.	Wanting at base.	Present.	Deep, circular, slightly expanded above.
	Ova.	Conical.	Two.	Present.		
	Ova.	Conical to sub-cylindrical.	One.	Plainly developed.	Pinnate.	Superficial.
	Ova.	Sub-conical with broad base.	One.	Thick.	Indistinct.	Circular. Edge projects above septa.
	Ova.	Various, generally conical.	One.	Rather strong.	Pinnate.	Very deep, extending nearly to base.
	Ova.	Conical.	One.	Present.	Pinnate.	Strongly deepened.
	Ova.	Sub-conical.	One.	Present.	Present.	Deeply concave.
	Ova.	Bowl-shaped or short conical.	One.	More or less strong.	Indicated.	Superficial.
	Ova.	Sub-discoidal or bowl-shaped.	One.	Present on the base.	Indistinct.	Superficial, plane or even convex.
	Ova.	Discoidal.	One.	Wanting.	Present.	Superficial.
	Ova.	Bowl-shaped or short conical.	One.	Present.	Indicated.	Superficial.
	Ova.	Discoidal.	One.	Strong on flat base.	Radiate.	Very shallow or nearly obsolete.
	Ova.	Discoidal or short conical.	One.	Strong on base.	Faint.	Superficial.
	Ova, lateral gemmation.	Sub-conical to cylindrical.	One.	Plainly developed.	Distinct.	More or less deepened.
	Ova.	Conical to cylindrical.	One.	Well developed.	Distinct.	Circular, moderately deep, with thin margins.
	Ova.	Conical.	One.	Present.	Distinct.	Deep and spacious.
	Ova, lateral gemmation.	Conical to cylindrical.	One.	Plainly developed.	Present.	Not deepened.
	Ova, calicinal gemmation.	Patellate, short conical to cylindrical.	One.	Thin.	Broad.	More or less deepened, frequently with central pit.
	Ova.	Conical or with slender stem.	One.	Present.	More or less distinct.	Shallow and very oblique.
	Ova, lateral, calicinal gemmation.	Cylindrical or prismatic.	One.	Thin.	Distinct.	Moderately deep, with thin margins.
	Ova, calicinal gemmation.	Conical, cylindrical or prismatic.	One.	Present.		Rather deep.
	Calicinal gemmation.	Confluent.	None.			Small pit with elevated rim.

	FOVEÆ.	SEPTA.
1.	One, well developed.	Numerous; both orders reach columella.
2.	None.	Reach center. Apparently in multiples of six, 12 at the base and 18 in the calyx.
3.		Well developed, alternating; second order very short.
4.		Completely developed. Numerous, closely placed.
5.		
6.	One, deep.	Smooth; consisting of three orders, the third very rudimentary.
7.		Both orders equally developed. Complete only near the base, raised folds above.
8.		Alternating. Primaries extend nearly to center, secondaries about half way.
9.		Alternating. Sides smooth, denticulate on inner edges.
10.	None or very obscure.	No lamellar septa, simply rows of spines.
11.	One, slightly developed.	Not regularly radiate, but inclined towards the stronger principal septa. Thick.
12.	One, well developed.	Exsert, extending nearly to center. Rather regularly radiate. Secondaries rudimentary.
13.	One large and three smaller ones.	Unequally developed and irregular. Pinnate to principal septum.
14.	One is developed.	Short, not reaching over half way to center. Alternating, secondaries marginal, somewhat inclined to primaries.
15.	One is indicated.	Numerous, alternating, strong. Primaries nearly reach center. Side faces granulated.
16.		Spines instead of true septa. Sometimes united by sclerenchyma into more complete lamellæ.
17.	One generally present and well characterized.	Short, equal or alternating. May sometimes reach center as low ridges on the tabulæ.
18.	One, lengthened and containing septum.	Numerous, unequal, irregularly arranged. Pinnate in one-half of calyx.
19.	Wanting.	Radiate, alternate. Primaries do not reach center. Secondaries one-half as long.
20.	Wanting or rudimentary.	Radiate, equal or alternate. Seen in calyx as broadening convex bands. Not sharply crested except near center.
21.	One on posterior side. Obscure in type.	Obscure or obsolescent. Fine, converging about the fovea; appear as mere ridges on the tabulæ.
22.	None indicated.	Radiate and alternate in type, primaries reaching nearly to center. Rudimentary in other species.
23.	Seemingly rudimentary.	Radiate, alternate. Primaries extend to center.
24.	None indicated.	Alternating, complete only in the tube-like channels. Primaries form a false columella. Extend outside as bands.

	DISSEPIMENTS.	TABULÆ.	CENTRAL AREA.
	None.	*None in typical species.	Strong, continuous, styliform columella.
	None.	None.	Columella wanting or non-determinable.
	Slightly developed.	None.	Thin, funnel-shaped inner wall.
	None.	None.	No columella.
	None.	None.	Styliform columella.
	None.	None.	Open to near base.
	None.	Horizontal, complete, at irregular distances.	No columella.
	None.	None.	No columella.
	None.	None.	No central structures.
	None.	None.	No columella. Some septa reach center.
	None.	None.	No columella.
	None.	None.	No columella.
	None.	None.	Broad and smooth.
	None.	Described as wanting.	Inner edges of primaries free and denticulate.
	None.	Well developed, horizontal, reaching to the spiny septa.	No central structure except the tabulæ.
	No true dissepiments.	Very strong, complete. Frequently bent downward near the wall.	Smooth and flat, septa being absent.
	None.	Little developed.	No columella.
	None.	Complete, horizontal.	Free from septa, only tabulæ present.
	Well developed in the narrow interseptal cavities.	No true tabulæ.	Septa may be somewhat twisted. Transverse dissepiments.
	None.	Complete, invaginated. Very oblique and closely arranged.	Only the oblique, smooth tabulæ.
	None.	Numerous, strong, horizontal. Not deflected at outer edges.	Generally smooth. No columella.
	None.	Variously formed, but extend to outer wall.	No columella.
	Abundant between the superposed layers.	Numerous in the visceral cavity. Bell-shaped.	False columella.

* Some species, as *Cyathaxonia dalmani*, have been found to possess tabulæ and *Lindströmia* has been proposed for such forms by Thompson and Nicholson (1876).

	MISCELLANEOUS.	NEAREST RELATIVES.	
1.	Principal septum is placed in the fovea. Columella is vesicular or tubular.	1. Lophophyllum. 2. Haplophyllia.	
2.	Septa protrude at the base as a small cone.	Petraia.	
3.	Septa of first order spread out at their inner edges to form secondary wall.	Aulophyllum.	
4.		Petraia.	
5.			
6.	Columella is formed of two smooth conical processes, thick at the base and tending to fill up the inter-septal cavities.	Cyathaxonia.	
7.	Compartmented only in short basal portion.	1. Turbinolopsis. 2. Cenophyllum.	
8.	The four principal septa are stronger and form a cross.	Phryganophyllum.	
9.	Lindström considers the species of Lonsdale and Phillips as Cyathophylla.	Petraia.	
10.		Acanthodes.	
11.	Fovea with three principal septa form a cross.	Hadrophyllum.	
12.	Principal septum is in fovea, to which the neighboring septa are rather pinnate.	1. Mycrocyclus. 2. Palæocyclus.	
13.	The four foveæ form a cross, but are not always distinct.	Baryphyllum.	
14.	Principal septum placed in the fovea.	Combophyllum.	
15.	Duncan has found tabulæ and vesicles in P. rugosus, E. and H., and includes genus under Cyathophyllum.	Combophyllum.	
16.	The spines are short and represent septa in lowest stage of development.	Acanthocyclus.	
17.	An appearance of simple dissepiments may be produced near wall by branching of tabulæ.	1. Zaphrentis. 2. Calophyllum.	
18.	Principal septum dwarfed and in fovea. The three others strongly developed, thus forming a cross.	Polycœlia.	
19.	Quite generally regarded as synonymous with Amplexus.	Amplexus.	
20.	Septa are formed of regularly superposed membraniform layers, non-continuous, with supporting growths.	Cyathophyllum, (simple forms of helianthoides).	
21.	Broad, shallow vesicles may be formed by incomplete continuity of tabulæ.	Amplexus.	
22.	Has not been considered as a rugose coral, but its characters bring it into this group.	Cyathophylloides,(compound forms).	
23.	This genus is placed intermediate between Amplexus and Zaphrentis in regard to its septal development.	1. Amplexus. 2. Zaphrentis.	
24.	Composed of superposed laminæ impressed with the cell pits.	Strombodes.	

DISTINGUISHING CHARACTERISTICS.	RANGE.	MAXIMUM.	DISTRIBUTION.
1. Absence of tabulæ and dissepimental structures. Columella forms a single, continuous rod. 2. Character of base and columella.	Silur., Carbon.	Carbon.	Europe, America.
Epitheca wanting at the base. Septa seemingly in multiples of six.	Silur.	Silur. (Niag.)	America.
Total absence of tabulæ. Wall is thin and funnel-shaped. Secondary septa very short.	Carbon.	Carbon.	Europe.
More completely developed septa and hence more shallow calyx.	Silur.	Silur.	Europe.
	Recent.	Recent.	
Character of base and columella. Recent.	Recent.	Recent.	America.
1. Considered synonymous by some. 2. Calyx very deep; septa complete only near base.	Silur., Devon., Carbon.	Silur.	Europe, America.
	Silur., Carbon.	Carbon. (Permian.)	Europe.
Difficult to separate and considered synonymous by some.	Silur., Carbon.	Silur.	Europe.
Simple, bowl-shaped or short conical. Absence of tabulæ.	Silur.	Silur.	Europe.
But one fovea, indistinct, which with the three principal septa form a cross.	Devon.	Devon.	Europe, America.
1. Absence of epitheca. Much longer septa. 2. Distinct fovea, to which septa are pinnate. No epitheca.	Devon.	Devon.	Europe.
Has four foveæ which form an indistinctly defined cross.	Devon.	Devon.	Europe, America.
Well developed epitheca. Septa are much shorter, leaving a broad, smooth, central area.	Devon.	Devon.	America.
Presence of epitheca. Fovea is indistinct, septa radiate and strongly granulated on faces.	Silur.	Silur.	Europe, America.
Simple or aggregated, sub-conical to cylindrical in form. Tabulæ quite well developed.	Silur.	Silur.	Europe.
1. Shorter septa and less pronounced fovea. 2. Fovea present. Regarded as including this genus.	Silur., Devon., Carbon.	Low. Carbon.	Europe, America.
Lengthened fovea containing dwarfed septum. Weaker development of tabulæ.	Silur., Devon.	Silur.	Europe, America.
Has no fovea, but this is quite generally considered as non-distinctive.	Silur.	Silur.	Europe, America,
Septa are not vertical plates but formed of superposed layers. Tabulæ absent. Interseptal cavities very narrow near wall. No carinæ.	Silur., Devon.	Devon.	Europe, America.
Septa consist of mere ridges over the tabulæ. Tabulæ are quite oblique.	Devon.	Devon. (Cornif.)	America.
Stronger and more numerous tabulæ. Septa ordinarily are not so complete; at times rudimentary.	Silur.	Silur.	Europe, America.
1. Not always simple. Longer septa. 2. Shorter septa. Not always simple.	Silur.	Silur.	Europe.
False columella.	Silur.	Silur.	Europe.

Family	Sub-family	No.	GENUS.	FOUNDER.	TYPE.	GROWTH.
FAM. II. EXPLETA.	SUB-FAM. I. Diaphragmatophora.	25.	Densiphyllum.	Dybowski, 1873.	D. THOMSONI.	Simple or fasciculate.
		26.	Grewingkia.	Dybowski, 1873.	G. (CLISIOPHYLLUM) BUCEROS, EICHW.	Simple.
		27.	Heterophrentis.	Billings, 1875.	H. SPATIOSA.	Simple.
		28.	LOPHOPHYLLUM.	Edwards and Haime, 1850.	L. KONINCKI.	Simple.
		29.	Menophyllum.	Edwards and Haime, 1850.	M. TENUIMARGINATUM.	Simple.
		30.	Metriophyllum.	Edwards and Haime, 1850.	M. BOUCHARDI.	Simple.
		31.	Palæophyllum.	Billings, 1858.	P. RUGOSUM.	Fasciculate or aggregate.
		32.	Pentaphyllum.	De Koninck, 1872.		Simple.
		33.	Phryganophyllum.	De Koninck, 1872.		Simple.
		34.	Polydilasma.	Hall, 1852.	P. TURBINATUM.	Simple.
		35.	*PTYCHOPHYLLUM.	Edwards and Haime, 1850.	P. STOKESI.	Simple.
		36.	Pycnophyllum.	Dybowski.		Simple or compound.
		37.	Pycnostylus.	Whiteaves, 1884.	P. GUELPHENSIS.	Aggregate.
		38.	** Siphonaxis.	Dybowski, 1873.	S. TUBIFERUS.	Simple.
		39.	STREPTELASMA. (Streptoplasma, Hall).	Hall, 1847.	S. EXPANSUM.	Simple.
		40.	ZAPHRENTIS. (Caninia, Mich.)	Rafinesque and Clifford, 1820.	Z. (CANINIA) PATULA, MICH.	Simple.
	SUB-FAM. II. Plenophora.	41.	Acanthophyllum.	Dybowski, 1874.		Simple.
		42.	† ACERVULARIA. (Astræa, Lam., pars.)	Schweigger, 1820.	A. RŒMERI.	Astræiform or fasciculate.
		43.	ACROPHYLLUM.	Thompson and Nicholson, 1876.	A. (CLISIOPHYLLUM) ONEIDÆNSE, BILL.	Simple.
		44.	Aspidophyllum.	Thompson, 1874.		Simple.
		45.	AULACOPHYLLUM.	Edwards and Haime, 1850.	A. (CANINIA) SULCATUM, D'ORB.	Simple.
		46.	Aulophyllum.	Edwards and Haime, 1850.	A. EDWARDSI, DUN. AND THOMP.	Simple.
		47.	AXOPHYLLUM.	Edwards and Haime, 1850.	A. EXPANSUM.	Simple.
		48.	BLOTHROPHYLLUM.	Billings, 1859.	B. DECORTICATUM.	Simple or in cæspitose clusters.

* Fungia, (pars) Lam.; Fungites, (pars) Schloth.

** Lindström states that this genus was founded upon silicified and altered fragments of an indeterminate coral.

INCREASE.	FORM.	WALLS.	EPITHECA.	COSTÆ.	CALYX.
Ova, calicinal gemmation.	Sub-cylindrical or curved conical.	One.	Plainly developed.	Present.	Little deepened.
Ova.	Conical.	One.	Plainly developed.	Present.	Rather shallow. Knob-like elevation at center.
Ova.	Turbinate.	One.	Present.	Present.	Large and deep.
Ova.	Conical.	One.	Complete.	Strong.	Moderately deep. Strong projection from the center.
Ova.	Conical.	One.	Complete.	Present.	Large and deep.
Ova.	Turbinate.	One.	Complete.	Present.	Moderately deep.
Ova, lateral gemmation.	Sub-conical.	One, thick.	Well developed.	Present.	Rather deep.
Ova.	Turbinate.	One.			
Ova.	Turbinate, short pedicled.	One.			Deep.
Ova.	Turbinate.	One.	Present.	More or less distinct.	Broad, margin thick, deep central pit.
Ova.	Short conical.	One.	Rather well developed.	Distinct and broad.	Basin-like. More or less deepened.
Ova, gemmation.		One.			
Ova, calicinal gemmation.	Cylindrical, slender.	One.	Present.	Present.	
Ova.	Conical.	One.	Present.		
Ova.	Conical, or conico-cylindrical.	One.	Well developed.	More or less distinct. Pinate.	Moderately deep.
Ova.	Turbinate, conical or conico-cylindrical.	One.	Thin.	Plainly marked.	Deep, generally with thin margins.
Ova.	Sub-cylindrical.	One.			
Ova, calicinal gemmation.	Prismatic or cylindrical.	One, or two.	Present, also as a common covering.	Present.	Abrupt central pit with explanate margins.
Ova.	Turbinate or conico-cylindrical.	One.	Thin.	Present.	Rather deep with generally a strong projection.
Ova.	Turbinate or conico-cylindrical.	One.	Complete.	Distinct.	Rather shallow. Helmet-shaped eminence at center.
Ova.	Turbinate, conical.	One.	Present.	Distinct.	Rather deep and spacious.
Ova.	Conico-cylindrical, curved.	Two.	Complete.	More or less distinct.	Deep, thin around periphery. Central cup-shaped projection.
Ova.	Turbinate.	Two.	Complete.	Present.	Moderately deepened, circular or slightly deform'd
Ova, calicinal gemmation.	Conico-cylindrical.	One.	Thin, complete.	Present.	More or less deepened.

† (?) Medusæphyllum, Roemer; (?) Asterocyclus, Vanuxem.
Astræophyllum, Nicholson and Hinde (1874), is now considered by Mr. G. J Hinde as a silicified and weathered Strombodes.

	FOVEÆ.	SEPTA.
25.	None indicated.	Regularly radiate; those of first order always reach center; secondaries much shorter.
26.	Seemingly none.	Regularly radiate, very strong, equal. Extend to false columella.
27.	One, well defined.	Sharp edged, sub-equal or alternating, inner edges twisted together frequently. Generally rounded near wall.
28.	One, quite well marked.	Extend nearly to center, small secondaries are generally present.
29.	One, well marked. Two smaller lateral ones.	Thin, straight and alternating. Pinnate in one-half of calyx, in other half short and radiate.
30.		Well developed, primaries reaching center and curving some. Secondaries rudimentary.
31.	None indicated.	Radiate, alternate. Primaries unite towards center and are irregularly twisted.
32.	One is present.	Numerous. Principal septum small and placed in fovea.
33.		Numerous.
34.	None indicated.	Numerous, thin, rising in pairs. Alternating, longer reaching center.
35.	One, which is generally well marked.	Radiate, alternate, broad. Generally angular towards the outer area. Primaries reach center.
36.		Radiate, alternate; primaries reaching center.
37.		
38.		Radiate in the calyx; each order extending into the columella. Each septum formed of two layers.
39.	One, which may be obscure or obsolete.	Radiate, alternate. Primaries extend into central structure.
40.	One, large and deep.	Variously formed, equal or alternating. Primaries generally reach center. Thickened towards the wall.
41.		Well developed. Side faces are supplied with thorny growths.
42.	None indicated.	Radiate, alternate. Primaries extend to near center, secondaries to pit with thickened extremities. Carinæ sometimes occur.
43.	One, well marked.	Well developed, alternating, lamellar; usually prolonged over surface of tabulæ to center as curved striæ.
44.	One, well marked.	Numerous, sub-equal or alternating. Primaries extending only to central area. Delicate in outer vesicular zone.
45.	One, distinct, in form of a narrow groove.	Numerous, well developed, thick. Radiate in one-half of calyx, in other half pinnate to fovea.
46.	Variable in size, but usually well marked.	Well developed, alternate. Primaries extend to central area and give rise to curved plates which fold around columella and form the inner wall.
47.	One, little deepened.	Generally alternating in length and thickness. Septa extend from outer wall to center.
48.	One, generally distinct.	Radiating and strong in the intermediate area. Rudimentary on the projecting surfaces of the cell cups.

	DISSEPIMENTS.	TABULÆ.	CENTRAL AREA.
	Outer zone of structureless sclerenchyma; probably vesicular.	Variously formed and extending only to peripheral zone.	Septa not twisted at center.
	None.	Nearly complete. Strongly convex upwards.	Large, spongy columella.
	None.	Apparently but a single one forming floor of calyx.	Smooth or with a pseudo-columellar structure.
	No true vesicular structure.	Convex, irregular. Complete with more or less interruption.	Central, compressed, non-continuous columella.
	None.	Elevated and crescent-shaped in one-half of calyx.	Smooth, no columella.
	No true vesicles.	Horizontal, well developed.	No columella.
	None.	None or rudimentary.	A false, spongy columella.
	None.	Obsolete or rudimentary below base of cup.	Primaries become complicated or contorted.
	Coarse and formed mainly by the continuous cell cups.	Cell cups form distinct tabulæ through the center.	False columella formed by twisting of primaries.
	Thick, structureless endotheca in periphery.	Not extending across the entire visceral cavity.	No columella.
	None.	Horizontal and embracing.	
		Plainly developed and extending to the wall.	Columella present and formed of little tubes.
	No true dissepiments.	Sometimes complete, but usually poorly developed and even obsolete.	A spongy central core occupies the axis.
	No true vesicles. Indicated by branching tabulæ.	Generally complete and well developed. Horizontal.	Septa may be slightly twisted. No columella.
	Present in periphery.	Present in central area.	
	More or less developed.	Incomplete and rather poorly developed.	Septa generally leave a free open space.
	Remote, angular, but becoming dense in outer zone.	Strong, non-vesicular, incomplete. Elevated and twisted.	Conical, obliquely contorted eminence.
	Minute vesicular tissue in periphery.	Confined to center, close-set, vesicular. Somewhat concave upward.	Elevated. Formed by tabulæ and a few radial, vertical plates.
	Very simple if any.	Moderately developed.	No columella.
	More or less developed.	Confined to central area, thin and irregularly horizontal.	A tube-like, nearly central and columellar-like wall.
	Rather coarse in external area.	Strong, remote and confined to center.	A comparatively gigantic, strong columella.
	Very simple if present at all.	Frequently complete and formed of the cell cups; flat at center.	Smooth, or with septa reaching center as low ridges.

	MISCELLANEOUS.	NEAREST RELATIVES.	
25.	Dybowski did not determine the nature of the outer zone. Provisionally placed in this division.	Pycnophyllum.	
26.	The columella is formed by manifold, irregular twisting and anastomosing of the primary septa.	Streptelasma.	
27.	Bottom of calyx may be smooth, have a conical tubercle, a small ridge or a variously formed columellar projection.	Zaphrentis.	
28.	Columella is generally in continuity with small septum in fovea and sometimes with opposite, primary septum.	Cyathaxonia.	
29.	Principal septum in principal fovea, towards which is turned the concavity of the crescentiform tabulæ.	Amplexus.	
30.	Septa are arranged in four groups but no cross is formed.	Zaphrentis.	
31.	Loosely aggregated in its growth.	Streptelasma.	
32.	The two septa bounding the fovea and the three principal septa strongly developed. Sometimes but four strongly developed septa occur.	1. Phryganophyllum. 2. Polycœlia.	
33.	Four large principal septa form a right-angled cross.	Polycœlia.	
34.	One septum of each pair stronger than the other.	Zaphrentis.	
35.	The septa are formed by a sharp infolding of the continuous cell cups. Type has radiciform processes.	Omphyma.	
36.		Densiphyllum.	
37.	Not more than two or three ascending stems produced.	Amplexus.	
38.	The fine tubes forming the columella are branched and anastomosed.	1. Streptelasma. 2. Grewingkia.	
39.	The spongy core seems to be formed by contortions of the septa and the introduction of additional structure.	1. Palæophyllum. 2. Grewingkia.	
40.	Tabulæ are frequently deflected downwards near the wall. Fovea is formed by a coalescence of septa.	1. Amplexus. 2. Cyathophylloides.	
41.		Heliophyllum.	
42.	A secondary wall is indicated about the pit by a thickening of the septa. A true wall seldom occurs.	1. Endophyllum. 2. Cyathophyllum.	
43.	Central eminence is formed entirely by the elevated and twisted tabulæ and not by the septa.	Köninckophyllum.	
44.	The vertical plates of the central area are quite independent of the septa. Median one is stronger and in fovea.	1. Dibunophyllum. 2. Clisiophyllum.	
45.	The pinnate septa may, alternately, intercross at the bottom of the fovea. Flexuous and irregular.	* Hallia.	
46.	The inner wall divides the visceral chamber into a central, columnar and an outer, annular area.	Cyclophyllum.	
47.	Columella is formed of numerous, vertical, spirally twisted lamellæ.	Lonsdaleia.	
48.	Distinctly made up of a series of invaginated cell cups with projecting edges. Wall is frequently absent.	Cyathophyllum.	

* From an examination of *A. mitratum*, Dr. Lindström considers the genus of doubtful value. Mr. G. K. Greene has in his possession over a hundred specimens the type, *A. sulcatum*, from the Falls of the Ohio, which he writes proves the

DISTINGUISHING CHARACTERISTICS.	RANGE.	MAXIMUM.	DISTRIBUTION.
Regarded as synonymous by Zittel and Lindström, but retained by Thompson.	Silur.	Silur.	Europe.
Tabulæ strongly convex upward. Large columella projecting in the calyx; character of which differs from that of Streptelasma.	Silur.	Silur.	Europe.
Pseudo-columella generally present. Apparently but a single tabula.	Devon.	Devon. (Cornif.)	America.
Tabulæ complete. Non-continuous columella in contact with two of the principal septa.	Devon., Carbon.	Carbon.	Europe, America.
Presence of the three foveæ and the crescentiform tabulæ.	Carbon.	Carbon.	Europe.
The quadrifascicular arrangement of the septa.	Devon.	Devon.	Europe.
Differs simply in being compound.	Silur.	Low. Silur.	America.
1, 2. Principal septum is stunted and in fovea. Bounding septa and three other principal septa strong.	Carbon.	Carbon.	Europe.
	Carbon.	Carbon.	Europe.
Much weaker development of tabulæ.	Silur.	Silur. (Niag.)	America.
False columella, single fovea, and general absence of radiciform processes.	Silur., Devon.		Europe, America.
Zittel and Lindström include Densiphyllum under this genus.	Silur.	Silur.	Europe.
Corallum is branched.	Silur.	Silur. (Niag.)	America.
1, 2. Columella is composed of fine, anastomosing, branching tubes instead of being spongy.	Silur.	Silur.	Europe.
1. Growth is simple. 2. See Grewingkia.	Silur., Devon.	Silur.	Europe, America.
1. More completely developed septa and fovea. 2. Simple. See also Heterophrentis, Polydilasma, etc.	Silur., Devon., Carbon.	Devon.	Europe, America.
Instead of carinæ the side faces of the septa have thorny outgrowths.	Silur., Devon.	Silur.	Europe.
1. Septa complete in outer area. Epitheca well developed. 2. Inner wall present or indicated. Septa shorter.	Silur., Devon.	Devon.	Europe, America.
Columella is in the form of a vertical plate instead of a compressed median rod.	Devon.	Devon.	Europe, America.
1. The central area is not completely divided by a strong median lamella. 2. Eminence helmet-shaped, character of tabulate area.	Low. Carbon.	Low. Carbon.	Europe.
Fovea is not replaced by a principal septum.	Silur., Devon.	Devon.	Europe, America.
No columellar structure within inner wall; composed of radial lamellæ united by vesicular structure.	Devon., Carbon.	Carbon.	Europe, America.
Simple. Septa better developed in outer area and reaching the outer wall.	Carbon.	Carbon.	Europe, America.
Stronger projecting cell cups; more rudimentary septal and vesicular development.	Silur., Devon.	Devon.	America.

genus to have been founded upon a *Cyathophyllum*. Prof. James Hall has referred eleven species to the genus.

FAM. II. EXPLETA. SUB-FAM. 2. Plenophora.

	GENUS.	FOUNDER.	TYPE.	GROWTH.
49.	Campophyllum.	Edwards and Haime, 1850.	C. (CYATHOPHYLLUM) FLEXUOSUM, GOLDF.	Simple.
50.	Carcinophyllum.	Thompson and Nicholson, 1876.		Simple.
51.	Chonaxis.	Edwards and Haime, 1851.	C. VERNEUILI.	Astræiform.
52.	CLISIOPHYLLUM.	Dana, 1846.	C. CONISEPTUM, KEYS.	Simple.
53.	CRASPEDOPHYLLUM. (Crepidophyllum Nich. and Thom.)	Dybowski. 1873.	C. (DIPHYPHYLLUM) ARCHIACI, BILL.	Simple or fasciculate.
54.	*CYATHOPHYLLUM.	Goldfuss, 1826.	C. DIANTHUS.	Simple, fasciculate, or astræiform.
55.	Cyclophyllum.	Duncan and Thompson, 1867.	C. (AULOPHYLLUM) BOWERBANKI, E. & H.	Simple.
56.	Cymateophyllum. (Kumatiophyllum.)	Thompson and Nicholson, 1876.		Simple.
57.	Dibunophyllum.	Thompson and Nicholson, 1876.		Simple.
58.	Dinophyllum.	Lindström.	D. INVOLUTUM.	Simple.
59.	**DIPHYPHYLLUM.	Lonsdale, 1845.	D. CONCINNUM.	Fasciculate.
60.	Endophyllum.	Edwards and Haime, 1851.	E. BOWERBANKI.	Astræiform.
61.	HALLIA.	Edwards and Haime, 1850.	H. INSIGNIS.	Simple.
62.	HELIOPHYLLUM.	Hall, 1846.	H. HALLI, E. AND H.	Simple or fasciculate.
63.	Holocystis. (Tetracocœnia. Lonsd.)	Lonsdale, 1849.	H. (CYATHOPHORA) ELEGANS, LONSD.	Astræiform.
64.	Köninckophyllum.	Thompson and Nicholson, 1876.		Simple or fasciculate.
65.	† LITHOSTROTION.	Lhwyd, 1699. Fleming, 1828.	L. BASALTIFORME, FLEM.	Fasciculate or astræiform.
66.	Lonsdaleia. (Stylidophyllum, From.)	McCoy, 1849.	L. DUPLICATA, MART.	Fasciculate or astræiform.
67.	OMPHYMA.	Rafinesque and Clifford, 1820.	O. (MADREPORA) TURBINATA, LINNE'.	Simple.
68.	PACHYPHYLLUM.	Edwards and Haime, 1850.	P. BOUCHARDI.	Simple or astræiform.
69.	PHILLIPSASTRÆA. ‡(Smithia, E. and H.)	D'Orbigny, 1849.	P. HENNAHI.	Astræiform.
70.	†† Pholidophyllum.	Lindström, 1870.		Composite.
71.	Rhodophyllum.	Thompson, 1874.		Simple.
72.	Spongophyllum.	Edwards and Haime, 1851.	S. SEDGWICKI.	Astræiform.

*Includes Madrepora, (pars) Linné; Peripœdium, Ehren.; Pterorhiza, Ehren.; Turbinolia, (pars) Lam.; Siphonophyllia, D'Orb.; Exostega, Raf. and Cliff.; Campsactis, Raf. and Cliff.; Floscularia, (pars) Eichw.; Strephodes, McCoy; Discophyllum, Hall; Polyphyllum, From.; Disphyllum, From.; Bothrophyllum, Trautschold; Ellipsocyathus, D'Orb.; Montastræa, (pars) Blain.; (?) Palastræa, McCoy; (?) Patinula, Eichw. and Palæosmilia, E. & H.

INCREASE.	FORM.	WALLS	EPITHECA.	COSTÆ.	CALYX.
Ova.	Conical or sub-cylindrical.	One.	Complete.		Deep; smooth flat center.
Ova.	Conico-cylindrical and cornute.	One.	Present.	Present.	Variable, sometimes everted.
Ova, gemmation.	Prismatic.	One, inner.			
Ova.	Turbinate or conico-cylindrical.	One.	Complete.	Present.	Variable, circular. Center has a prominent conical boss.
Ova, lateral gemmation.	Cylindrical or conico-cylindrical.	Two.	Complete.	Distinct.	Moderately deep with small flat center.
Ova, lateral, calicinal gemmation.	Conical, cylindrical or prismatic.	One.	Complete.	Distinct.	Deepened.
Ova.	Conico-cylindrical. Tall.	Two.	Thin.	Present.	Deep, with thin edges. Shows a secondary circular cup.
Ova.	Conico-cylindrical. Tall.	One.	Thin.	Present.	Circular, shallow, more or less everted.
Ova.	Turbinate or conico-cylindrical.	One.	Complete, thin.	Present.	Usually shallow. Has a rounded eminence.
Ova.	Conical.	One.	Present.	Strong.	
Ova, lateral and calicinal gemmation. Fission.	Cylindrical.	Two.	Complete, thin.	Distinct.	Moderately deep.
Ova and gemmation.	Sub-cylindrical to prismatic.	Two.	Absent.		
Ova.	Turbinate to conico-cylindrical.	One.	Present.	Distinct.	
Ova and calicinal gemmation.	Turbinate to conico-cylindrical.	One.	Complete, usually thin.	Distinct.	Various, seldom deep. Sometimes with projecting bottom.
Ova, extra-calicinal gemmation.	Prismatic.	One.	Absent.	Well developed.	Sub-polygonal. A simple, thick mural ridge.
Ova, calicinal gemmation.	Conical, cylindrical or conico-cylindrical.	One.	Complete, thin.	Present.	Moderately deep. Contains a projection from center.
Ova, calicinal and lateral gemmation. Fission.	Cylindrical or prismatic.	One.	Complete.	Distinct.	Moderately deep with strong projection.
Ova, calicinal gemmation.	Cylindrical or prismatic.	One or two.	Complete.	Distinct.	Of moderate dimensions with a projection.
Ova.	Turbinate.	One.	More or less developed.	Present.	Generally deepened with a smooth bottom.
Ova, lateral gemmation.	Prismatic.	None.	Present as a common covering.	Distinct on outer corallites.	Small, pit-like, surrounded with a rim.
Ova, sub-marginal gemmation.	Prismatic.	One?	Present as a common covering.	Present on outer corallites.	Margins expanded, central pit with rim.
Ova, calicinal gemmation.		One.	Present.	Present.	
Ova.	Conico-cylindrical. More or less curved.	One.	Complete, thin.	Present.	Circular, shallow, contains a dome-shape boss.
Ova and gemmation.	Prismatic.	One.	Present.		

† Includes Nematophyllum, McCoy; Stylaxis, McCoy; Siphonodendron, McCoy; Petalaxis, E. and H.; Stylina, Lesueur; Lithodendron, Phil.; Axinura, Castelnau; Stylastræa, Lonsd.; Acrocyathus, D'Orb.; Lasmocyathus, D'Orb.; Astræa, (pars) Lam.; Arachnium, Key.; Nemaphyllum, McCoy and Lithostrotium, Bronn.

†† Includes Tryplasma, Lonsd.; Scarithodes, Dyb. and Acanthocyclus, Dyb.

[illegible]

	FOVEÆ.	SEPTA.
49.	One is occasionally present.	Short, alternating, fall considerably short of center. Secondaries quite marginal.
50.	One is present.	Well developed, alternating. Do not extend to center.
51.		Lamellar and well developed towards center. But slightly or not at all prolonged into vesicular area.
52.	One, more or less distinct.	Well developed, alternating. Primaries never extend further than outer edge of central boss.
53.	A wide fovea is generally present.	Well developed, alternate; with denticulate edges. Primaries join the two walls. Secondaries shorter.
54.	Not distinct but occasionally present.	Well developed, radiate, equal or alternating. Primaries extend to center. Side faces and edges smooth.
55.	One, variable in size, but well marked.	Numerous, well developed, alternate. Primaries extend to columellar wall. Thin in the outer area.
56.	One, well marked.	Usually thin, alternating. Flexuous in outer area. Primaries extend only to outer margin of central area.
57.	One, well marked.	Well developed, generally of two orders. Primaries always fall short of central area. Secondaries short or wanting.
58.	Present as a narrow groove.	Meeting at the center and forming an elevated and columella like whorl.
59.	Obscure or obsolete.	Radiate, alternate. Primaries seldom reach the center; secondaries generally enter the tabulate area.
60.	None indicated.	Septa project but slightly outside of well marked internal wall. Alternating, flexuous.
61.	None.	Well developed, alternate. Regularly radiate in one-half of calyx, in other half pinnate to large principal septum.
62.	One, more or less distinctly developed.	Well developed, alternate, radiate. Primaries extend to center or its immediate vicinity. Frequently flexuous.
63.	One, deep.	Slightly exsert, closely set, very thick exteriorly. Not reaching center. Slightly granulated laterally.
64.	Occasionally one.	Well developed but always fall short of columella. Thin and delicate in vesicular zone, but reaching wall. Alternating.
65.	One is sometimes inconspicuously present.	Radiate, alternate. Various in extent, sometimes reaching columella. Sides smooth, not denticulate.
66.	Obscure or none.	Generally alternating. Rudimentary or obsolete in vesicular area. Primaries ordinarily do not reach columella.
67.	Four, although three are seldom distinct.	Numerous, equal or alternating. Broad, with tent-shaped crest in calyx, at times sharp, seldom rounded.
68.	Obscure or none.	Well developed, alternate. Poorly developed in vesicular zone. More or less thickened about pit. Somewhat confluent in neighboring corallites.
69.	Rudimentary or obsolete.	Alternate, primaries unite at the center. Secondaries terminate at rim of calicinal pit.
70.		Equal.
71.	One, well marked in cross section.	Alternate. Primaries extend only to outer edge of central boss; secondaries sometimes scarcely observable.
72.	None indicated.	Numerous, very slender, confined to central area. Generally lost in the outer vesicular zone.

DISSEPIMENTS.	TABULÆ.	CENTRAL AREA.
True vesicular outer zone of variable width.	Well developed, extending over large central area but not to wall.	Tabulæ smooth, flat and free from septa.
Present throughout the corallum.	Loose, vesicular and rudimentary.	An elongated, slightly raised, central boss.
Dense vesicular zone in external portion.	Limited to central area.	Lamellar columella.
Minute vesicular tissue arranged in inclined rows.	Present as central, very delicate, elevated, inosculating plates.	Continuous, columellar lamina.
Developed to a greater or less extent in outer area.	Confined to central tube-like channel. Horizontal or slightly inclined.	Distinct secondary wall. Entire or horse-shoe shaped.
Generally well developed.	Incomplete, confined to a central area of various extent.	Septa may become twisted. No columella.
Present in outer area. Delicate and irregular at center.	Irregular, incomplete, vesicular and anastomosing. Elevated at center.	Distinct inner wall enclosing a loose columella.
Form a dense zone in outer area.	Confined to center, interrupted, close-set, concave.	Raised, over which sinuous ridges extend to center.
Scanty in central area, abundant in outer.	Central, delicate, anastomosing; elevated centrally but markedly concave upwards.	Low central eminence. Formed by independent, straight lamellæ and tabulæ.
	Elevated toward the center.	Elevated as in Clisiophyllum.
Confined to a narrow peripheral zone. At times a single row.	Well developed in broad central area. Deflected at outer edges.	Tabulæ smooth, generally free from septa.
Much developed and coarse outside of inner wall; finer within.	Small.	Septa may or may not reach center. No columella.
More or less developed.	Present.	Inner edge of large principal septum simulates a columella.
More or less developed. Sometimes nearly absent.	Incomplete; confined to a more or less extensive central area.	Septa may unite with each other. No columella.
Simple, horizontal or slightly convex.	Thick, close-set, not complete.	Small styliform columella.
Numerous, close-set; forming a dense outer zone.	Delicate, close-set, inosculating, almost vesicular. Elevated at columella.	Laterally compressed, sometimes discontinuous, columella.
Small and delicate in outer area. Do not interfere with septa.	Various in extent, frequently bifurcating and irregular. Sometimes centrally elevated.	Laterally compressed, rod-like, continuous columella.
Large, forming an outer vesicular zone.	Well developed, close-set, often anastomosing. Elevated at columella.	Large continuous columella formed of twisted plates.
Coarse and formed mostly by continuous, plicated cups.	Well developed through the central area, horizontal and smooth.	Flat and generally free from septa. No columella.
Abundant in outer area, more or less developed at center.	Well characterized through the center.	Primary septa are thin and reach center.
Present in peripheral area.	Wanting or rudimentary.	Weak, false columella.
Loculi filled with "like-formed" stereoplasma.	Regular, equidistant.	
Outer zone of dense tissue in which septa are thin.	Irregular, vesicular, very delicate. Slightly concave upwards between the lamellar plates.	Formed by tabulæ and a few vertical, spirally twisted plates.
Fill up the larger portion of the visceral cavity.	Some small, horizontal tabulæ at the center.	No columella nor inner wall.

	MISCELLANEOUS.	NEAREST RELATIVES.
49.	The tabulæ are quite simple and may be remote or crowded. May extend nearly to wall.	1. Amplexus. 2. Cyathophyllum.
50.	The central area is occupied with a reticulate cellular tissue.	Centrocellulosum.
51.	The internal wall is stated to be well marked. Outer wall is wanting.	Lonsdaleia.
52.	The central boss is formed by the conical tabulæ and a few independent vertical lamellæ, straight or spirally twisted.	* Rhodophyllum.
53.	Side faces of the septa are carinated as in Heliophyllum and some species of Acervularia.	1. Diphyphyllum. 2. Heliophyllum.
54.	The septa may fall short of center, or in some species may be quite twisted.	Heliophyllum.
55.	Columella is spongiose and contains some vertical, radiating, thin, discontinuous, more or less numerous, lamellæ.	Aulophyllum.
56.	The central area is composed of thin, irregular, wavy, discontinuous, columellarian plates.	Centrophyllum.
57.	Central area is bisected by a median lamella, one extremity of which is directed towards the fovea.	Aspidophyllum.
58.	"Near the epitheca there exists a peculiar kind of intraseptal structure, consisting of narrow twisted strings of whitish color."	Clisiophyllum.
59.	Secondary wall generally marginal and formed by inner faces of the vesicles. Corallites frequently connected by mural expansions.	1. Craspedophyllum. 2. Cyathophyllum.
60.	External wall rudimentary, without epitheca; inner is sometimes double. Between the two structure is nearly entirely vesicular.	Acervularia.
61.	The fovea is replaced by a strong principal septum which extends beyond the center.	Aulacophyllum.
62.	Side faces of septa are supplied with carinæ, extending in a curve from the wall towards center. Convex upward.	1. Craspedophyllum. 2. Cyathophyllum.
63.	Septa form three complete cycla and four well characterized systems. Four primaries give a conical appearance to calyx.	Stauria.
64.	Tabulate area may be more or less extended. When fovea is present it contains a single short septum.	1. Axophyllum. 2. Lonsdaleia.
65.	An internal wall, similar in character to that seen in Diphyphyllum, is sometimes indicated near the outer.	1. Diphyphyllum. 2. Köninckophyllum.
66.	A distinct inner wall is sometimes present between the vesicular and tabulate area. Columella is vesicular.	1. Chonaxis. 2. Lithostrotion.
67.	Septa are formed by superposed, sharp, inwardly directed folds of the continuous cell cups. Radiciform processes.	Ptychophyllum.
68.	The septa in neighboring corallites are more or less confluent.	Phillipsastræa.
69.	Septa are confluent in neighboring corallites, sometimes carinated strongly. An inner wall is sometimes indicated.	Pachyphyllum.
70.	Costæ are arranged in pairs. Simple specimens show a row of rhombic scales on each half of a longitudinal plication.	
71.	Calicinal boss is low, rounded and traversed by the few spirally twisted ridges. Has no median crest.	Clisiophyllum.
72.	Septa seem to merely striate the surface of the vesicles in the outer zone.	1. Endophyllum. 2. Lonsdaleia.

* The genera *Dibunophyllum*, *Aspidophyllum*, *Rhodophyllum*, *Cymatcophyllum*, *Centrophyllum*, *Histiophyllum* and *Albertia* are very closely related to *Clisiophyllum*, and may be separated from it and from one another only by closest attention to the details of the central area.

DISTINGUISHING CHARACTERISTICS.	RANGE.	MAXIMUM.	DISTRIBUTION.
1. True vesicular structure. Incomplete tabulæ. 2. Much shorter septa and weaker vesicular structure.	Devon., Carbon.	Devon.	Europe, America.
Septa never reach center. Reticulate central structure instead of cells.	Low. Carbon.	Low. Carbon.	Europe.
Absence of outer wall.	Carbon.	Carbon.	Europe.
Centrally elevated tabulæ. Calicinal boss is conical. Vertical plates more numerous and complete at center.	Silur., Devon., Carbon.	Carbon.	Europe, America.
1. More nearly central and heavier inner wall. Carinæ. 2. Inner wall and shorter septa.	Devon.	Devon.	America.
Septal faces smooth; heavier vesicular development. See also Blothrophyllum, Diphyphyllum and Acervularia.	Silur., Devon., Carbon.	Devon.	Europe, America.
Inner area is filled with a spongiose columellar structure containing vertical, radiating lamellæ.	Carbon.	Carbon.	Europe.
The vertical plates of the central area are not so plainly developed.	Low. Carbon.	Low. Carbon.	Europe.
Median lamella extends across central area instead of half way. Eminence is low and rounded.	Low. Carbon.	Low. Carbon.	Europe.
Septa continue to the center; character of interseptal structure.	Silur.	Silur.	Europe.
1. Inner wall is marginal and weaker. No carinæ. 2. Always compound. Inner wall, shorter septa, etc.	Silur., Devon., Carbon.	Devon.	Europe, America.
Absence of epitheca. Septa are but little developed between the two walls.	Devon.	Devon.	Europe.
The fovea is replaced by a strong septum to which neighboring septa are pinnate.	Silur., Devon.	Silur.	Europe, America.
1. No inner wall, septa longer. 2. Presence of carinæ, slighter development of vesicles.	Silur., Devon.	Devon.	Europe, America.
Deep fovea, septa very thick towards wall, arranged in three cycla, strong costæ, no epitheca.	Cretaceous.	Cretac.	Europe.
1. Laterally compressed columella. Dense vesicular zone and fine inosculating tabulæ. 2. Septa reach outer wall.	Carbon.	Carbon.	Europe.
1. Generally astræiform. Presence of columella. 2. Always compound, weaker vesicular development and stronger septa.	Devon., Carbon.	Carbon.	Europe, America.
1. Outer wall is present. 2. Septa weak in outer area, vesicles large, sub-cylindrical columella formed of twisted plates.	Silur., Carbon.	Carbon.	Europe, America.
No columella, four foveæ in type, broad central area, strong radiciform processes.	Silur.	Silur.	Europe, America.
Well characterized tabulæ at the center.	Devon.	Devon.	Europe, America.
Tabulæ at the center are obsolete or rudimentary.	Devon., Carbon.		Europe, America.
	Silur.	Silur.	Europe.
Calicinal boss not conical. Tabulæ slightly concave upwards. Comparatively few central, vertical, incomplete plates.	Low. Carbon.	Low. Carbon.	Europe.
1, 2. No internal wall. Septa reduced to mere striæ in periphery. 2. No columella, less tabular development.	Devon.	Devon.	Europe.

Group		No.	GENUS.	FOUNDER.	TYPE.	GROWTH.
FAM. II. EXPLETA.	SUB-FAM. II. Plenophora.	73.	Stauria.	Edwards and Haime, 1850.	S. ASTRÆIFORMIS.	Astræiform or subfasciculate.
		74.	*STROMBODES.	Schweigger, 1820.	S. PENTAGONUS, GOLDF.	Confluent.
		75.	Syringophyllum. (Sarcinula, Dana.)	Edwards and Haime, 1850.	S. (MADREPORA) ORGANUM, LINNE.	Astræiform.
		76.	Thysanophyllum.	Thompson and Nicholson, 1876.		Fasciculate or astræiform.
		77.	Trochophyllum.	Edwards and Haime, 1850.	T. VERNEUILANUM.	Simple.
	TRIBE 1.	78.	Bucanophyllum.	Ulrich, 1886.	B. GRACILE.	Simple.
		79.	Cystiphorolites. (Vesicularia, Rom. 1876.)		C. (VESICULARIA) MAJOR, ROM.	Aggregate or astræiform.
		80.	CYSTIPHYLLUM. (Conophyllum, Hall.)	Lonsdale, 1839.	C. SILURIENSE.	Simple or loosely aggregate.
		81.	Cystostylus.	Whitfield, 1880.	C. TYPICUS.	Fasciculate.
SUB-FAM. 3. Cystophora.	TRIBE 2.	82.	Clisiophylloides.	Dybowski, 1873.		
		83.	Elasmophyllum.	Hall, 1882.	E. ATTENUATUM.	Simple.
		84.	Microplasma.	Dybowski, 1873.		Fasciculate.
		85.	Plasmophyllum.	Dybowski, 1873.		
	Tribe 3.	86.	Fletcheria.	Edwards and Haime, 1851.	F. TUBIFERA.	Fasciculate.
		87.	Rhizopora.	De Koninck, 1872.		Fasciculate.
	TRIBE 4.	88.	Aræopoma.	Lindström, 1883.	A. (CYSTIPHYLLUM) PRISMATICUM.	Simple.
		89.	Calceola.	Lamarck, 1801.	C. SANDALINA.	Simple.
		90.	Goniophyllum.	Edwards and Haime, 1850.	G. (TURBINOLIA) PYRAMIDALE, HIS.	Simple.
		91.	Rhizophyllum.	Lindström, 1865.	R. GOTHLANDICUM.	Simple.
ADDENDA.	PLENOPHORA.	92.	** Albertia.	Thompson, 1878.		Simple.
		93.	Centrocellulosum.	Thompson.		Simple.
		94.	Centrophyllum.	Thompson, 1880.		Simple.
		95.	Fasciculophyllum.	Thompson, 1883.	F. DYBOWSKI.	Simple.
		96.	Heterophyllia.	McCoy, 1849.		Simple.
		97.	Histiophyllum.	Thompson, 1879.		Simple.

*Includes Strombastræa, Blain.; Lamellopora, Owen; Cylicopora, Stein.; As- [illegible] Lam.; Arachnophyllum Dana and Actinocyathus D'Orb.

INCREASE.	FORM.	WALLS.	EPITHECA.	COSTÆ.	CALYX.
Ova, calicinal gemmation.	Prismatic or cylindrical.	One.	Complete.	Wanting.	Generally rather deep.
Ova, submarginal gemmation.	Laminated, with vertical tubes.	None.	Common covering on base.		Polygonal when defined. Shallow with central pit.
Ova, lateral gemmation.	Prismatic.	One, strong.	Present.	Well developed.	Circular, prominent with rim; rather shallow.
Ova, calicinal gemmation.	Cylicindrical or prismatic.	One.	Stout.	Present.	Shallow.
Ova.	Trochoid, horn-shaped.	One.		Probably present and large.	Shallow.
Ova.	Trumpet-shaped.	One.	Present.	Faint.	Deep.
Ova, calicinal gemmation.	Turbinate to confluent.	None.	Apparently a thin, common epitheca.	Epitheca is costulated.	Broad, shallow, or abrupt with central pit and rim.
Ova, gemmation.	Various. Conical or conico-cylindrical.	One.	Complete but thin.	More or less distinct.	Shallow and basin-like or deepened.
Ova, lateral gemmation.	Cylindrical.	One.	Present.		Deep and funnel-shaped.
					Elevated centrally.
Ova.	Turbinate.	One.			
	Sub-cylindrical.				
Ova, calicinal gemmation.	Cylindrical.	One, thick.	Complete.		Circular or slightly deformed. Edges thin.
Ova, gemmation.	Cylindrical.	One.	Thick, wrinkled.		Circular.
Ova.	Quadrangular-prismatic.	One, strong.	Present.	Distinct.	Square; quite deep.
Ova.	Half-conical; slipper-shaped.	One.	Complete, heavy.	Faint.	Deep, pointed.
Ova.	Quadrangular-pyramidal.	One.	Heavy.	More or less distinct.	Square, somewhat deepened.
Ova.	Half-conical.	One, thick.	Complete, strong.	Indistinct.	Deep, semi-circular, pointed.
Ova.	Conico-cylindrical, curved, tall.	One.	Thin.	Present.	Circular, shallow and sometimes everted.
Ova.	Conico-cylindrical, curved, small.	One.	Variable.	Present.	Deep, thin around margin.
Ova.	Conico-cylindrical or cornute.	One.	Thin.	Present.	Circular, moderately deep, sometimes everted.
Ova.	Conico-cylindrical, curved, small	One.	Variable.	Present.	Variable in depth.
Ova.	Cylindrical, tapering to a point.	One.	Stout.	Prominent	Shallow, with septa everted.
Ova.	Conico-cylindrical, rather tall, curved.	One.	Usually thin.	Present.	Usually shallow, more or less everted.

	FOVEÆ.	SEPTA.
73.	Rudimentary.	Large and smooth. Four principal ones stronger and projecting unite at center to form a cross.
74.	Small one is sometimes observed.	Numerous, generally extending to center and uniting. Confined to central core. Extend over expanded calicinal margins as rugæ.
75.	None indicated.	Well developed, large, projecting. Extending nearly to the center of calicinal pit.
76.	May be present.	Do not reach the outer wall; equal or alternating.
77.	Rudimentary.	Equal, thick, straight and regularly radiate. Edges entire. Extend nearly or quite to center.
78.		Fine, radiating septal striæ in the calyx.
79.	None indicated in original specimens.	Rudimentary. At the outer edges they appear as low, linear crests, gradually vanishing towards the center.
80.	Quite distinct in some species, obsolete in others.	Rudimentary and frequently obsolete. May appear as rows of spines or as sharp crests, becoming rounded rugæ at wall.
81.	None indicated or mentioned.	Septa are obsolete.
82.		Incompletely formed.
83.		Extend to center where they may or may not be twisted.
84.		Stunted; rows of spinulose forms or small closely compressed lamellæ.
85.		Incompletely developed.
86.		Rudimentary.
87.		Rudimentary.
88.	One, more or less distinct.	Rudimentary, but quite distinct. Low, spiny ridges lost beneath the vesicles towards the center.
89.	Present as a groove on curved side.	Diminished to slightly raised lengthened lines. Principal septum is on curved side, lateral ones at the angles.
90.	One, quite distinct on the slightly curved side.	Numerous, thick, well developed, reaching center. Principal septa are somewhat raised; situated at the middle of each flat side.
91.	Shallow, situated on curved side.	Principal septum may be somewhat projecting in the fovea. The others appear only as lengthened bands.
92.	Usually small but well marked.	Thin, alternating. Primaries extend only to outer margin of central area. Thin and flexuous in outer area.
93.	One is indicated; small.	Alternating. Primaries extend only to outer margin of cellular structure. Secondaries are minute.
94.	One, variable, usually well marked.	Variable, alternating. Primaries extend only to outer margin of elevated central boss. Thin and flexuous in periphery.
95.	One, of variable dimensions.	Alternating. Both orders extend towards center and coalesce, forming groups or fascicles.
96.	One present in large varieties.	Lamellar. Extend from wall to center, uniting into fascicles. Not generally alternating.
97.	One, well marked.	Well developed, alternating. Primaries extend only to outer margin of central area. Secondaries shorter, thin and disappearing

	DISSEPIMENTS.	TABULÆ.	CENTRAL AREA.
	Present in periphery.	Present in central portion of visceral cavity.	No columella.
	Occupying the spaces between the superposed laminæ.	Funnel-shaped tabulæ are present at the center.	No columella, but a papillose projection may occur.
	Present in interseptal and intercostal areas.	Small, but little developed.	Styliform columella indistinctly developed.
	Arranged in oblique rows.	Confined to broad central area. Remote.	Septa do not reach center. No columella.
		Poorly developed.	No columella.
	Fill up visceral cavity.		No columella.
	Coarse, cover the cell cups and more or less fill up cavity.	Present only as blistered, irregular cell cups.	Smooth and flat in calyx. Ridges at times reach center.
	Occupy entire visceral cavity. Coarse and lenticular.	Wanting or rudimentary; formed by the vesicles.	Smooth and flat. No columella.
	Fill up entire cavity. Comparatively coarse.	Almost obsolete in type. In C. infundibulus, funnel-shaped but incomplete.	No columella.
	Present.		
	Interlamellar cysts continue to center.	Wanting.	
	Coarse.		
	Rows of vesicles not arched upward at center.		
	Present.	Complete, horizontal, well developed.	
	Visceral cavity contains a meshy, vesicular structure.		
	Developed much as in Cystiphyllum.	Rudimentary or entirely absent.	No columella. Convex surfaces of the vesicles are distinct.
	Present in interseptal cavities.	None.	No columella.
	Present and forming a vesicular structure with the tabulæ.	Funnel-shaped and but little developed.	No columella.
	Present in the interseptal cavities.	Rudimentary or absent.	No columella.
	Dense zone in outer area: sparse within.	Interrupted and irregular. Concave at center, convex beyond.	A depression exists at the center of calyx.
	Sparse and remote.	Rudimentary and replaced by cells.	Occupied by a system of irregular, minute, spheroidal cells.
	Dense in outer area; fewer towards center.	Concave at center, convex in intermediate area.	Slightly elevated, with series of ridges converging towards center.
	Few and rectangular.	More or less rudimentary.	A reticulate structure is formed by union of the central septum of each fascicle.
	Fine and dense in a narrow outer zone.	Minute at center. Broad and convex in intermediate area.	Inner edges of septa form a pseudo columella.
	Abundant in outer area, fewer towards center.	More or less remote. Crowded and vesicular in some forms.	Central boss raised on dorsal side, depressed on ventral side, corresponding with tabulæ.

	MISCELLANEOUS.	NEAREST RELATIVES.
73.	Corallites may be free in part or united by their epithecal walls.	Cyathophylloides. (Compound forms.)
74.	Made up of a series of superposed laminæ, impressed with the cell pits. The rugæ in some species, have alternating pores.	Darwinia.
75.	Costæ are strongly developed and sloping down from rim are confluent. Much resembles Pachyphyllum in external appearance.	Pachyphyllum.
76.	The septa extend from the outer vesicular zone for a short distance towards the center.	1. Lonsdaleia. 2. Campophyllum.
77.	The fovea is indicated merely by the shortening of the principal septum.	1. Zaphrentis. 2. Cyathophyllum. (Simple.)
78.	Form is long, slender and terminated by an abruptly expanded cup.	Cystiphyllum.
79.	Corallites are formed by a series of superposed, blistered calicinal cups, confluent in neighboring stems.	Cystiphyllum.
80.	Septa are generally represented merely as low ridges or rows of spines extending over the vesicles.	1. Cyathophyllum. 2. Cystiphorolites.
81.	Corallites are parallel, wholly or partly in contact and united by transverse filaments. Stems are bifurcating.	Cystiphorolites.
82.	At the center the rows of vesicles are convex upwards forming an elevation in calyx.	Plasmophyllum.
83.	Lindström considers this synonymous with Cyathophyllum.	Cyathophyllum.
84.	Lindström considers this a Cystiphyllum.	1. Cystiphyllum. 2. Cyathophyllum.
85.	Lindström considers this a Cystiphyllum.	Clisiophylloides.
86.	Zittel states that a round or oval, concentrically wrinkled operculum exists.	Rhizopora.
87.		1. Cystostylus. 2. Fletcheria.
88.	An operculum of sub-triangular valves is said to be present. No trace of its attachment was observed in the specimens examined.	1. Goniophyllum. 2. Cystiphyllum.
89.	Supplied with a thick, semi-elliptical operculum, which has a strong median ridge.	Rhizophyllum.
90.	Slight depressions in the angles of the calyx. Operculum composed of four paired pieces meeting at the center.	1. Calceola. 2. Rhizophyllum.
91.	Operculum is simple, semi-elliptical with median ridge. Corallites have strong root-like appendages.	Calceola.
92.	Thin, curved lamellæ or ridges extend from inner edges of primaries to outer edge of central depression.	Aspidophyllum.
93.	Inner edges of the primaries are united to the central cells.	Fasciculophyllum.
94.	The central area is formed by the radial columellarian septa, united by the concave tabulæ.	Cymateophyllum.
95.	The secondary septa may be minute or may extend inwards for a considerable distance, uniting with the primaries.	Centrocellulosum.
96.	The broad tabulæ of the intermediate area are bent downwards near the wall and attached to it or to zone of vesicles.	Fasciculophyllum.
97.	Central radial lamellæ extend from inner edges of primaries, coalesce and form a more or less irregular rod.	Köninckophyllum.

DISTINGUISHING CHARACTERISTICS.	RANGE.	MAXIMUM.	DISTRIBUTION.
Four of the septa form a cross in the calyx. Absence of vesicles. See also Holocystis.	Silur.	Up. Silur.	Europe.
No defined columella.	Silur., Devon.	Silur.	Europe, America.
Strong walls, presence of columella. The corallites are more individualized.	Silur., Devon.	Silur.	Europe.
1. No true columella; uncovered central tabulate area. 2. Abortive condition of the septa.	Low. Carbon.	Low. Carbon.	Europe.
1. Rudimentary fovea and tabulæ. 2. Stunted principal septum in fovea. Coarse septa.	Carbon.	Carbon.	America.
Peculiar trumpet-shaped corallum.	Devon.	Low. Devon.	America.
Compound growth. Rudimentary condition of walls.	Silur.	Silur. (Niag.)	America.
1. Absence of true septa and tabulæ. Coarse vesicles. 2. Simple in growth, better defined wall.	Silur., Devon.	Devon.	Europe, America.
Slender, cylindrical and fasciculate in growth. Corallites bifurcated and united by transverse filaments.	Silur.	Silur. (Niag.)	America.
Rows of vesicles at the center elevated, forming a mound-like elevation in calyx.			
Absence of tabulæ.	Devon.	Devon. (Corni f.)	America.
1. More complete septal development. 2. Rudimentary condition of septa and coarse vesicles.	Silur.	Silur.	
Rows of vesicles not elevated at the center.			
Well developed, horizontal tabulæ. Concentrically wrinkled operculum present. Silurian.	Silur.	Silur.	Europe.
1. No infundibuliform arrangement of tabulæ. Not bifurcate. 2. Visceral cavity has coarse vesicular structure.	Carbon.	Carbon.	Europe.
1. More slender prismatic growth, and coarser vesicular structure. 2. General shape and operculum.	Silur.	Silur.	Europe.
Absence of radiciform processes.	Silur., Devon.	Devon.	Europe, America.
1, 2. Square pyramidal shape, more complete septa. 2. Absence of radiciform processes.	Silur.	Silur.	Europe, America.
Radiciform processes.	Silur., Devon.	Silur.	Europe, America.
Central depression in calyx. Lamellæ of central area do not reach center. All of same approximate thickness.	Low. Carbon.	Low. Carbon.	Europe.
General absence of the fasciculate arrangement of the septa. The spheroidal cells of the center.	Low. Carbon.	Low. Carbon.	Europe.
The radial septa of the central area are somewhat better developed.	Low. Carbon.	Low. Carbon.	Europe.
The fascicled arrangement of the septa and absence of central spheroidal cells.	Low. Carbon.	Low. Carbon.	Europe.
Corallites tall and more cylindrical. Secondary septa not generally present.	Devon. Carbon.	Carbon.	Europe.
The distinctly compressed median columellar rod towards which the tabulæ are elevated is absent.	Low. Carbon.	Low. Carbon.	Europe.

OIL AND GAS RESOURCES OF WEST VIRGINIA.

By I. C. White, Morgantown, West Va.

[Address delivered at the World's Fair banquet, Charleston, W. V.]

The desire to search out new and hidden things is universal. It weds alike the astronomer to his telescope, the chemist to his crucible, the philosopher to thought. Led by this enchantment, men explore the depths of the sea, delve into mountains, and seek to penetrate the earth itself to unveil its hidden mysteries. This all prevailing impulse is the mainspring of human progress. It led Col. Drake to drill the historic oil well in the valley of Oil creek below Titusville, which gave to civilization a new illuminant and to the business world a new industry.

The credit of originating the industries dependent upon oil and natural gas is usually awarded to Pennsylvania. This is not really true. West Virginia, and not Pennsylvania is the true birth place of both. Right here in this beautiful valley of the Kanawha, was natural gas first utilized for manufacturing purposes, 30 years before such use in Pennsylvania, while from the other Kanawha at Burning Springs, oil was shipped in barrels and a regular traffic in it built up many years before Pennsylvania's first well was drilled. In fact it was right here in the county of Kanawha (which generally leads the procession in business as well as in politics) that drilling tools and the method of casing wells were both invented, without which the oil and gas industry would have been impossible. All honor to the memory of Col. Drake for first conceiving and executing the plan of drilling into the earth to obtain oil. But in this connection let us not forget the names of the Ruffner brothers, whose busy brains invented casings; nor "Billy" Morris, who constructed the first pair of "jars," for without both of these discoveries, deep drilling would have been impracticable.

The question is frequently asked, why it is that, if West Virginia really contains so much oil, it was not discovered and developed along with that of her sister state. The answer is at hand. The first wells to find oil in our state were on the Little Kanawha, where a great arch in the rocks throws the oil sands much nearer to the surface than elsewhere in the state, and hence it happened that although wells were drilled in nearly every county west from the Alleghenies, none of them, until recent years penetrated the earth far enough to reach the oil bearing rock.

About eight years ago your speaker took up the serious study of oil and gas problems in Pennsylvania. The following year I became convinced that the great oil belt of that state would extend into and across our own. Acting on this conviction I had a map prepared almost exactly like the one you see here now. This I submitted to a Pittsburg firm and the theory of a southern extension of the Pennsylvania field appeared so plausible to them that they were induced to undertake the oil development of West Virginia on a large scale.

Under my direction over four hundred thousand acres of West Virginia lands were leased by my brother, H. S. White, who now does business for the United States. The Pittsburg syndicate drilled two wells on this immense area, and erected about eight derricks. The first was drilled for gas with which to supply Wheeling. Some gas was found, but not as much as the company expected. The second well was for oil, and located near Board Tree Tunnel at the southwest corner of Pennsylvania. This found only a small quantity of the golden fluid. The syndicate was discouraged. Its president declared there was neither oil nor gas in West Virginia, and bankruptcy would be the result of any further effort to find them. The "shut down" movement came on and a property which would have made Rockafellers of its owners was permitted to lapse and the leases to become void. Within sight of the Board Tree venture a valuable oil well was completed by the Standard Oil company during the past year.

One of my locations, made in 1885, before Mr. Hukill had drilled his first well at Mt. Morris, was one on the Youst farm near Fairview, in Marion county. Here a derrick had been erected, and I plead with the Pittsburg men to make this test before finally abandoning West Virginia. They were deaf to my appeal, and this old derrick to-day stands in the midst of a dozen oil wells, gushing from one to five hundred barrels each, and sending two thousand barrels of the finest oil in the world throbbing through the pipe line on its way to the sea. The Mt. Morris, Doll's Run, Fairview, Mannington, oil and gas field, whose southern end no one has yet found, and which in my opinion will prove the largest and richest oil and gas belt the world has ever known, was largely covered by the leases which the Pittsburg syndicate held.

Until the year 1889, the oil magnates of the country paid no

serious attention to West Virginia. This date, however, is a "red letter" one in our oil history, for it marks the opening of Doll's Run, Mannington, and the rise of Eureka to prominence. These three developments brought the Standard Oil Company to realize that here in West Virginia was to be the great oil field of the future and that much berated monopoly has come into our state to take possession of its oil business. How many hundred thousand acres it has leased or purchased I do not know, but the territory it controls is a vast one, and the million and a half dollars it has expended in building a pipe line from Morgantown to the sea attest that it is with us to stay. Just what its influence will be upon our young commonwealth remains to be ascertained. It is here at the capitol asking for legislation necessary for carrying on this vast business enterprise of producing and marketing the million barrels of oil which lie hidden in our rocky state. If what it asks be fair it is only right that it should be given. Most of us have only seen the dark side of this monster corporation. It is too true that its immense proceeds have been used in this country to crush out rivals whom it could not purchase, but at the same time, only the power of such aggregated wealth could meet and vanquish the Nobells and Rothchilds of Europe in the contest with the cheap oils of Russia. To meet this competition, and hold as well as extend the foreign market for American oils, this much abused corporation has often sold oil for months far below its cost, and had this not been done, the price of our oil would not be more than 50 cents a barrel to-day. This is one of the benefits that aggregated wealth confers, of which we hear very little.

It is my firm belief that this great oil belt which has come down to our state through a distance of 200 miles, will extend clear across the same from Hancock to Logan. Only to-day I received a telegram that a large flow of gas had stopped the drill at a well in Gilmer, while Maj. Hotchkiss, the eminent Virginian who has so eloquently depicted our rich mineral resources this evening, and who, although a native of another state, has done more to develop ours than any citizen in it, tells me that a well being drilled by his company in Lincoln, has had to shut down from the same cause. The gas wells at Warfield, on the Big Sandy, and those at Burning Spring, above this city complete the chain of evidence that the oil belt will extend entirely across our

area from the Pan Handle to Kentucky, for wherever the gas occurs the heavier fluid is not far away. How much of luxury and comfort this underground wealth will bring to the homes of our state, no man can estimate, but our future in this respect could not be brighter.

With the greatest coal field in the world, giving us an ample supply of solid fuel for all time to come; with this great stream of liquid gold coursing through our rocks, only waiting to be tapped; with the largest fields of natural gas the world has ever seen, to bring comfort and ease to our homes, where is the commonwealth whose future is brighter than ours? All that we need to do is to let the world know what we have. This we must depend upon our Representatives now in session in this city to accomplish. Business men pay very little attention to statements that do not bear official sanction. Hence it is to be hoped that in providing for a proper display of West Virginia's resources at the approaching World's Fair you will adopt a broad and liberal policy. And in whatever you may do, be sure to make provision for the preparation for an accurate map of the state. The miserable caricatures that we now have that are called maps of West Virginia, although infinitely better than none, are a disgrace to the state, so that if yon do nothing else, at least provide a splendid map upon which our wondrous resources in timber, in coal, in ore, in oil and gas can be exhibited.

THE WARRIOR COAL FIELD OF NORTHERN ALABAMA.

By Persifor Frazer, Philadelphia.

The levels above the tide of several points selected to represent roughly the average surface plane of northern Alabama in Cullman, Blount, Walker, Winston, Lawrence, and Morgan counties, are thus given in the records of major Fitzhugh, consulting and examining engineer Louisville and Nashville railroad, to whose courtesy I am indebted for them :

Louisville and Nashville Railroad.	Feet above mean tide.
Helena	407.00
Pelham	435.00
Siluria	484.40
Calera	504.00

Jamison	709.26
Montgomery	161.15
Birmingham	620.00
Boyle's (3 miles north of last)	524.00
Newcastle	514.00
Locust Warrior Bridge	417.25
Warrior Station	548.80
Reid's Station	591.72
Blount Springs	435.00
Mulberry Warrior Bridge	431.00
Hanceville	540.00
Phelan	693.00
Cullman	802.00
Sand Mountain	918.65
Willites	610.00
Hartsell's	666.50
Flint	575.00
Decatur	577.00

The last is a short distance north of any portion of the property in question, and on the Tennessee river.

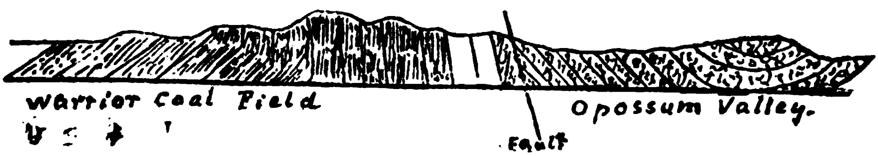
BIRMINGHAM MINERAL RAILROAD	Above tide.
Gurley Creek	638.0
Gurley's Bridge	644.0
Palmer's	723.0
Oneonta	859.0

The significance of the above detached data is that the state of Alabama, more especially the northern half of it, is a strongly accidented plane, sloping southwest, which forms a transition from the mountainous country of the Appalachian chain, entering Alabama from the north and east to the low country of the gulf border. It is in this region that the greatest structural feature of the eastern part of the North American continent disappears from view by plunging below the surface. This fact is a key to the proper understanding of its geology as well as of its topography. The hills in this country are synclinals made up of elevated concentric troughs of different strata lying one within the other, and the valleys are broken anticlinals, with sides sloping steeply towards the median line of the valley and the rocks dipping on each side inward towards the interior of the hills. A rough sketch taken from a manuscript section map of the Alabama geological survey,* kindly lent me by the state geologist, will illustrate this.

The anticlinal axes of the Appalachian mountains descend more

* Issued as part of the Cahaba coal field after the above was written

rapidly to the southwest from Tennessee to the gulf of Mexico than the drainage of the surface, and in consequence the further northeastward we go along the lines of these axes from the gulf to the Tennessee river the older do the strata covering the surface become. The greater part of the area referred to from Tuscaloosa to the vicinity of the Tennessee river in a northeast line is formed by the Carboniferous formations,—indeed by the Coal Measures which form their chief value. Therefore it may be said that along this imaginary axis in a northeasterly direction the geological "horizon" becomes lower and lower until at some six or seven miles below the town of Cullman the botton of the Coal Measures is reached and no coal belonging to the Coal Measures proper can be expected. It is quite true that there are other deposits of coal below the true Coal Measures which are of considerable value and



extent so near as the state of Tennessee, but the most careful and patient search on the part of the State geological survey and of private geologists and prospectors has led to the well founded belief that these beds of coal become so thin towards the south that they cannot be mined with profit south of the Tennessee river.

From this general explanation of the geological structure of the country, viz: that along the axes of the anticlinals and synclinals descending towards the sea the age of the strata covering the surface becomes more recent, it will follow also that the same must be true in proceeding in a direction oblique to the anticlinal valleys, for we then mount the synclinal elevations of which the strata have been preserved. We should therefore find the most recent strata on the top of the lines of hills, and the oldest in the bottoms of the valleys; this is the case, and the amount of the change depends upon the width of these elevations; for having arrived at the median line of one of them we thereupon commence to descend. These changes of "horizon" laterally are therefore limited in amount, and recur in similar succession as one traverses the separate spurs or fingers through which the Appalachian mountain system dies down beneath the surface in Alabama.

The more detailed references which follow will serve to show on

what this view of the writer is based, but at present it is the aim to condense, as far as possible, the results.

The "Warrior coal field" is a name given to the productive Coal Measures covering a large area in the northern part of the state of Alabama, and includes at least four and perhaps more principal beds which in descending order are the "Newcastle," the "Jefferson," the "Black Creek," and the "Warrior" seams. Inasmuch as the latter is the lowest, it must be found underneath the outcrops of any of the others, but the converse is, of course, not true; and while from its greater extent it is quite proper that its name should be given to the whole field, one must guard against the error of supposing that wherever this bed occurs the other and higher beds will also be found. Some erroneous estimates have been due to this confusion of terms.

A digest of the general section of the Coal Measures in Jefferson county, made with great care and skill by Mr. McCalley, the assistant State geologist, from his personal observations, aided by the researches of Mr. T. H. Aldrich and Mr. Howard Douglas, is here appended, because it gives in elaborate detail all the strata which are found in this part of the state, from the Pratt seam down to the base of the lower conglomerate.

It furnishes a complete inventory of all the valuable minerals within the Coal Measures north of the latitude of Birmingham and explains why so much of the coal deposits of Alabama is commercially valueless on account of the thinness of the beds and their admixture with slate. It is necessarily introduced here for reference in cases when the special coal development of a particular region is referred to (pp. 309 and 310).

The Hoene Warrior and Jefferson Coal company own, amongst other properties, about 250 acres of coal lands near the town of Warrior, known as the Alabama mines, and 2,794 acres in all, including the Brake and Jefferson mines. With the exception of a reported coal seam in Mr. Paris' well in the S. W. ¼ of Sec. 14 W., there are no outcrops of coal known hereabouts or in this country north and west of the ravines near Warrior station on the South and North Alabama railroad, in which are the mines of the Hoene Warrior and Jefferson Coal company, and the Pierce's Warrior Coal and Mining company, according to the State report. The Alabama coal mines are situated about a mile north by west from the town of Warrior, in a deep valley between steep hills

No. of beds counting from the bottom.		Thickness in Feet and Inches.
	Shale, massive and curly	75 ft. to 100 ft.
39	Coal	1 ft. to 1 ft. 6 in.
	Sandstones, hard, shaly, gray, micaceous, fossiliferous	40 ft.
38	Coal, guide seam soft	3 in. to 8 in.
	Fire clay	3 ft. to 4 ft.
	Sandstone, Shale, micaceous, gray. In heavy boulders. Reported to contain locally some impure lime carbonate, shales contain locally black band and clay iron-stone	100 ft to 200 ft.
37	Coal............(PRATT SEAM)	2 ft. to 7 ft.
	Fire clay	2 ft. to 10 ft.
	Sandstones, shales, clays	20 ft. to 30 ft.
	Coal (fire-clay seam, good)	1 ft. 4 in. to 2 ft. 6 in.
	Fire-clay	1 ft. to 1 ft. 6 in.
	Sandstones, shales, conglomerates	25 ft. to 40. ft.
	Coal	1 ft. 2 in.
	Clay-slate, fossiliferous, with coal	6 in. to 7 ft. 3 in.
35	Coal	1 ft. to 2 ft. 8 in.
	Clay-slate, fossiliferous	0 ft. to 1 ft. 9 in.
	Coal, good	0 ft. to 3 ft. 0 in.
	Sandstones, shales, clay slate	25 ft. to 175 ft.
34	Coal, irregular, slaty, balls of pyrite	1 ft. to 2 ft. 6 in.
	Sandstones and shales	30 ft. to 70 ft.
	Coal	0 ft. to 2 ft.
	Slate	0 ft. to 4 in.
33	Coal	6 in. to 4 ft.
	Slate, sandstone	8 in. to 7 ft.
	Coal	3 in. to 1 ft. 8 in.
	Shales, sandstones	5 ft. to 50 ft.
32	Coal	1 ft. to 2 ft. 6 in.
	Sandstones, shales, fossiliferous, with coal	20 ft. to 50 ft.
31	Coal	2 in. to 1 ft.
	Sandstones, shales. Latter contain clay-iron-stone	25 ft. to 50 ft.
30	Coal, with slate partings	10 in to 8 ft.
	Fire-clay	2 ft.
	Sandstones, shales. The latter contain sometimes clay-iron-stone and black-band	10 ft. to 50 ft.
	Conglomerates	0 ft. to 6 ft.
29	Coal, with thin slate parting	0 ft. to 1 ft.
	Shales, sandstones, limestone	50 ft. to 300 ft.
	Conglomerates	0 ft. to 7 ft.
	Sandstones	10 ft.
28	Coal, with slate parting....(CAL. WILLIAMS)	2 ft. 4 in. to 9 ft. 6 in.
	Sandstones, shales and clays	0 ft. to 12 ft.
	Coal, with slate partings	0 ft. to 6 ft.
	Fire-clay	3 ft.
	Sandstones, shales	20 ft.
27	Coal	0 ft. to 2 ft.
	Sandstones, shales	10 ft. to 50 ft.
	Coal, with slate partings	0 ft. to 8 ft.
	Fire-clay, sandstones, conglomerates, shales, slate	25 ft. to 50 ft.
25	Coal in places, thin	2 in.
	Sandstones with some coal and some clay-iron-stone in lower part	20 ft.
24	Coal	4 in. to 1 ft.
	Sandstones, shales	25 ft. to 30 ft.
23	Coal, (Baker's "upper bed," Walker county)	10 in. to 2 ft.
	Fire-clay, shales, sandstones	20 ft. to 50 ft.
22	Coal, slaty, throughout or in upper part (Baker's lower bed, Walker county)	2 ft. to 6 ft.
	Shales, sandstones	20 ft. to 40 ft.
	Black-band	2 ft.
	Shale, sandstone	5 ft. to 20 ft.
	NEWCASTLE.	
21	Coal with slate and clay partings (equivalent of the "Jagger," "Townley," "Mt. Carmel," "Hawthorne," &c., beds of Walker county, the "Newcastle" or "Big Vein" of Jefferson county)	5 ft. to 14 ft.
	Sandstones, Shales, Sometimes considerably clay-iron-stone (kidney ore) in upper and lower parts	15 ft. to 60 ft.

No. of beds, counting from the bottom.		Thickness in feet and Inches.
20	Coal, poor and slaty	10 in. to 3 ft 6 in.
	Fire clay	1 ft. to 3 ft.
	Sandstones, shales	10 ft. to 50 ft.
19	Coal, soft and bony in places	2 ft. 6 in.
	Shales, sandstones	15 ft. to 25 ft.
	Black-band	0 ft. to 1 ft. 4 in.
	Sandstones shales, sometimes conglomerates	15 ft. to 20 ft.
18	Coal, soft	0 ft. to 2 ft. 9 in.
	Fire clay	0 ft. to 1 ft.
	Shales (argillaceous, fossiliferous)	0 ft. to 12 ft.
	Coal, with seams of pyrite and slate	0 ft. to 4 ft. 9 in.
	Shales, sandstones	20 ft. to 25 ft.
	Conglomerates gray and hard	16 ft. to 40 ft.
	Slate	0 ft. to 1 ft.
17	Coal, bony,	1 ft. to 3 ft.
	Fire clay	0 ft. to 2 ft.
	Sandstones, shales	25 ft. to 125 ft.
16	Coal, peacock lustre	4 in. to 1 ft. 8 in.
	Sandstones, shales	30 ft. to 50 ft.
	JEFFERSON SEAM.	
15	Coal, thin slate parting	2 ft. to 4 ft.
	Sandstones	0 ft. to 9 ft.
	Coal	0 ft. to 1 ft. 6 in.
	Sandstones	0 ft. to 4 ft.
	Coal, very good	0 ft. to 0 ft. 9 in.
	Fire-clay	3 ft.
	Sandstones, shales	20 ft. to 50 ft.
	BLACK CREEK.	
14	Coal in one or two places said to be 6 ft	2 ft. 4 in,
	Sandstones, shales, limestone	50 ft. to 140 ft.
13	Coal	0 ft. to 1 ft.
	Sandstones, shales	60 ft. to 225 ft.
12	Coal	1 ft. to 1 ft. 2 in.
	Sandstones, shales	30 ft. to 125 ft.
	Black-band, coal	0 ft. 3 in. to 4 ft.
	Shale	0 ft. to 18 ft.
	WARRIOR SEAM.	
11	Coal	1 ft.
	Shale	0 ft. 3 in. to 17 ft.
	Coal.	2 ft. 4 in.
	Fire-clay	4 ft.
	Sandstones, shales	16 ft. to 20 ft.
	Coal	1 ft. 8 in. to 2 ft. 4 in.
	Sandstones, shales	7 ft. 6 in.
	NABER'S SEAM.	
9	Coal, hard	2 ft. 2 in.
	Fire-clay	6 ft. 10 in.
	Shales, sandstone, limestone; the sandstones with streaks of coal	295 ft. 6 in.
8	Coal, hard and bright	1 ft. 6 in.
	Fire-clay	1 ft.
	Sandstones, shales	16 ft.
7	Coal	1 ft. 4 in.
	Shales, with fossil coal plants	12 ft.
6	Coal	2 ft. 6 in.
	Sandstones, shales	500 ft.
5	Coal	0 ft. 6 in.
	Shales, sandstones	35 ft.
4	Coal	1 ft.
	Shales	5 ft.
	Conglomerates (upper congl. of Tennessee)	30 ft. to 50 ft.
3	Coal	1 ft.
	Shales, sandstones	50 ft.
	Conglomerates (lower congl. of Tennessee)	40 ft. to 75 ft.
2	Coal	1 ft.
	Shales, fossiliferous	3 ft. to 10 ft.
1	Coal (slaty)	0 ft. 10 in.
	Shales, sandstones	30 ft. to 35 ft.

just west of the Louisville and Nashville railroad; there are two tunnels about eighty yards apart, called respectively the North and the South Alabama works.

The measures are nearly horizontal to the eye, but in fact dip southwardly about 1 foot in 36 feet. These drifts are in the lowest of the principal coal beds of the coal series or the Warrior. At the face of the north opening, underneath 12 feet of sandstone and shale, is a layer of black-band of about 1 foot 8 inches, in contact with about 4 inches of kidney ore on its lower surface.

A fire-clay 3 feet to 5 feet thick is below the coal beds.

A vertical section gives:

Sandstone and shale	12 ft.	
Black-band with base of kidney ore	2 ft.	2 in.
Coal	0 ft.	8 in.
Slate	0 ft.	6 in.
Coal	2 ft.	0 in.
Fire Clay	4 ft.	6 in.

A fair sample of the coal was taken from the present working face at the extremity of the drift by the writer, and gave the following results:

	Per Cent.
Moisture (at 105° Cent.)	1.19
Volatile matter	29.46
Fixed carbon	64.66
Ash	4.69
Sulphur	1.57
Phosphorus	0.028

The black-band is here immediately above the coal. Where there is a considerable interval between the two, the expenses of mining each are materially increased. The roof is here fine coal slate. The mining work is extensive and well done. About 100 yards northward from the opening along the valley is an outcrop of black-band in the side of the hill 2 feet thick but not pure.

An average sample of the 20-inch thick seam of black-band from the working face in the drift where it was latest mined, was taken by the writer and gave the following results:

		Per Cent.
Moisture (at 105° Cent.)		0.25
Volatile matter	combustible	27.96
	non-combustible	8.84
Fixed carbon		20.31
Ash		42.64
Ferrous oxide (Fe O)		24.14

Ferric oxide (Fe_2O_3)	10.71
Carbonic acid	None
Sulphur	0.384
Phosphorus	0.286

About 300 feet from the mouth in this drift the coal measures 20 inches. Its analysis will also be found with the rest.

Throughout the drift the Warrior seam and its overlying black-band vary somewhat in thickness, but more in their distance apart. The measures throughout exhibit very great variability in thickness and relative position, and this is true of the whole Warrior field, so far as it has been observed by the writer. Two feet two inches seemed to represent an average of the larger seam of coal, however. It was slightly less than this at the present working face.

A 4-inch thick clay vein dips south 10°, west 15° near the top of the slope.

This represents the general direction of inclination of the strata, but is much steeper than the average dip.

I visited the shore of the Locust Warrior, passing by the Watts mines, and the deposit of sand washed out by the river and accumulated at one of its bends opposite Turkey creek. A specimen of this sand yielded on analysis 96.56 per cent. silica. This has been washed out of the numerous loose sand rocks by the river, and deposited at the point where its current has been obstructed, and the materials in suspension have been allowed to fall. There ought to be many such accumulations along this stream, as the rocks are easily disintegrated, the current is at seasons very strong and rapid and the channel of the river is sinuous.

This deposit was estimated to be 600 feet broad and ten feet thick, tapering off on each side of the elbow in the stream at points a couple of hundred yards apart.

One hundred yards northeast of the sand exposures is a deposit of brick clay of good quality. An analysis showed it to contain:

Silica	78.20
Ferrous oxide	0.35
Alumina	12.20

Its extent was not well defined. Ascending the hill north at about 70 feet above the river, a conglomerate occurs with quartz and rounded pebbles dipping steeply about south 10 east.

At the Watts mine, a drift is run in about 60 feet above the level of the Locust Warrior, and a coal seam is exposed dipping

gently north 10° west, 3 feet thick, and with a strong slate roof. This is on the Jefferson coal seam in the hills, above which hard conglomerate is seen, and also a minor seam of coal, probably No. 16 of the State survey General Section of Jefferson county. At the foot of the incline leading down from the tipple, and 300 yards up the river are the signs of the out-crops of the Black Creek vein 2 feet thick.

The Warrior bed is probably far below this (it is thought 250 feet).

The Brake mines are situated about 2½ miles south by west of Warrior town.

About ten yards in the slope of this mine, an 18-inch coal seam dips northwest 10°. The bottom is in soft clay and the top is in hard sandstone. At the foot of the slope the Jefferson vein appears.

Thirty feet below the Jefferson seam, but not yet opened up by the slope, is the Black Creek. The manager thinks that 90 feet more in the present direction of the slope would reach it. Here again the conglomerate is seen on the hill-tops, about 75 feet above the Jefferson vein. It is in this place a conglomerate of quartz and amethystine pebbles, with other rounded stones in a matrix of loose, friable sandstone.

The Jefferson mines, across the river were not visited, but it is universally conceded that they are on the Jefferson seam, and that they include the small coal seam No. 16 of the General Section before referred to. In the shaft of the Jefferson mines, the assistant State geologist makes it clear that the highest bed of coal penetrated is a small bed (18 of the General Section, Jefferson county,) which is at least 66 feet below the Newcastle bed, though it has been erroneously supposed that this seam was represented in the strata penetrated. It really cuts the strata from 18 to 14 (Black Creek) of the General Section.

In this connection the coal near Bremen, called that of the Bremen basin, by major Fitzhugh, should be considered.

By following the Stout road about 6½ miles south by west from the town of Cullman, the line of coal-bearing hills begins to be reached. The road is through sandstones and conglomerates over which come, in regular succession, the higher measures, as explained in the introduction, until finally the real coal-bearing strata appear. But many small seams occur north of the line, out of

which coal has been irregularly picked to supply the needs of the neighborhood for domestic purposes.

The first of the coal openings visited lay in northwest ¼ south 7, Range 3, Township 12, almost on the line between Blount and Cullman counties. This point is about 13 miles south by west of the town of Cullman, and 70 feet lower than the station rail (by uncorrected barometer), or 732 feet above tide. The exposure is called Day's opening, and a rough measurement gave:

Sandstone and shale	?
Coal	1 ft. 6 in.
Clay	1 ft. 5 in.
Coal	2 ft. 4 in.

This coal is without question the equivalent of the Black Creek bed in Jefferson county.

Hill's exposure, a short distance from the preceding, is evidently on the same coal. A section of it gave:

Roof sandstone	?
Clay	0 ft. 3 in.
Upper Seam	0 ft. 18 in.
Clay	1 ft. 9 in.
Lower seam	2 ft. 4 in.

The general dip was south 15 degrees east.

About a mile west of this is the Cullman Land company's openings, exposing a coal seam in a ditch run in some 60 feet. A section of this cut shows—

Sandstone	?
Clay	0 ft. 2 in.
Coal	1 ft. 2 in.
Clay	1 ft. 0 in.
Coal	2 ft. 9 in.

Average samples were taken of the lower and upper seams of coal respectively, with the following results:

	Specimens dried at 105° Cent.	
	Lower Seam. Per Cent.	Upper Seam. Per Cent.
Volatile matter	31.06	36.79
Fixed carbon	65.50	42.00
Ash	3.44	21.21
Sulphur	0.184	0.078
Phosphorus	0.017	0.012

There were numerous outcrops of ferruginous sandstones found here, but no iron ore.

CULLMAN COUNTY.

The whole of this county is composed of the lower Coal Measures, and although in the southwest near the Bremen district one and probably two, of the lower important seams of coal in the Alabama field occur, and the whole county is interspersed with small coal seams, yet it is very probable that no deposit of sufficient size to make it commercially valuable will be found northeast of the imaginary northwest-southeast line six or seven miles southwest of the town of Cullman, which has already been referred to. A small six-inch vein worked in the bed of a creek about three miles west of Cullman in the dry season has furnished coal to the citizens of Cullman and the neighboring farmers through the enterprise of a citizen of that town. Iron ores have been reported from various directions also, but none were observed.

On account of the report of a valuable bed of coal in the northern part of the county on Flint creek, I made a visit to it. About a mile or so northeast of the town of Cullman a conglomerate occurs, and underneath this is a small seam of coal. This is one of the two conglomerates often called the Upper and Lower Tennessee conglomerates, which mark the base of the true Coal Measures, and the coal occurs in these seams within 12 to 15 feet of shales. At about two miles northeast of Holmes' Gap, variegated shales form the surface rock, lying very nearly horizontally. At Drake's house, which by uncorrected barometer is 175 feet above Cullman station, or 977 feet above tide, is the summit between Bridge creek and the east fork of Flint creek.

On the steep hills descending northward to the latter fragments of conglomerate appear. A drift has been driven in about 65 feet nearly on a level with the surface of the stream, which, when in flood, fills it. The floor of this drift is 415 feet below Drake's house, or 562 feet above tide (by uncorrected barometer). At the mouth of the drift is a very lean and dirty coal mixed with clay and sand, in all 2 feet thick. The section is as follows:

Cap sand rock	?
Lean and slaty coal	0 ft. 1 in.
Sandstone	1 ft. 6 in.
Bony coal mixed with clay and sand	2 ft. 0 in.

At the head of the drift the coal runs out altogether, unless an extremely impure carbonaceous clay of about one inch in thickness may be called coal. This drift proves that the coals of the sub-

conglomerate and lower conglomerate measures in this region occur in lenticular masses and run out in all directions, forming merely roughly defined horizons of fossil vegetable matter. It shows, moreover, that in this region these deposits cannot be depended upon to supply any considerable quantity of fuel with regularity.

At 150 feet above Flint creek, on the right bank, is a small 6 inch seam of coal, 40 feet above which is a conglomerate 8 feet thick. Along this ridge between Flint and Lick creeks the same small and capricious coal bed is seen always close to the conglomerate. At a natural portico made by a huge overhanging ledge of conglomerate from which a small stream plunges to the hills below, the coal was an impure layer of 14 inches on one side and at a distance of 50 feet about 7 inches on the other. In some places it seems to disappear altogether. The measures here seem to dip gently southeast.

A hole had been drilled on the hill northeast of the Flint creek drift and about 260 feet above it, which proved the presence of a hard conglomerate beneath the surface.

Almost one-fifth of Cullman county, or that portion lying in the southwest corner is underlain by valuable seams of coal. This fraction holds the "Black Creek" and "Warrior" seams. The territory near Warrior contains, besides, the "Jefferson," and in some cases one or two of the unreliable small beds of coal above it, but not any so high up in the series as the "Newcastle."*

There is also here a workable black-band seam, one element in the value of which is that near Warrior it occurs close enough to the Warrior coal vein to enable both to be mined at once. The relative positions of these veins, as of all other strata in this coal field, change very greatly within short distances, and it is not at all certain that the area over which the ore will be found to be a workable deposit is as large as that in which the Warrior coal vein may be confidently expected.

No ores were seen in the portion of these lands personally inspected which would engage the serious attention of an iron master, though it is quite probable that valuable ores occur on some of the detached southeastern sections in other counties.

The timber in Cullman county is excellent and abundant. Particular acres were found by Dr. Mohr, of Mobile, to contain as much as 30,000 feet B. M. and many unselected acres as much as 15,000 feet. Its quality appears to be admirable.

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* See Note II. at the end.

Since the experiment has been made of adding a small quantity of guano to each cotton seed planted, the cotton crop on the light, sandy soil of Cullman county has been found excellent in quality and averaging perhaps half a bale to the acre. The State geologist, however, deprecates this employment of the land and thinks that the cultivation of fruit and vegetables would be more appropriate and more profitable.*

The following statement is taken from the advance sheets of the United States Census for 1890, sent to the writer;

PRODUCT AND VALUE OF COAL IN ALABAMA IN 1889.

Counties.	No. of mines.	Total Product.	Coked.	Value of Product.	Average Price Per Ton.
Jefferson	20	2,305,383	824,354	$2,485,744	$1.08
Etowah, Blount, Cullman, Cherokee	16	5,255	....	9,278	1.77
All counties	44	3,378,384	982,271	3,707,426	1.10

The salubrity and fertility of the Cullman lands are unquestioned. The country is well watered and is under cultivation by the German colony which Mr. Cullman has established there, one of the most successful in the United States. The industry and sobriety of this community are admirable and in striking contrast to the shiftless and careless husbandry which they replaced. The existence of such a class of farmers in Cullman county is of itself a strong recommendation of the lands and an inducement to further settlement. It would be difficult to present this advantage too strongly.

To sum up:

The lowest well known workable bed (neglecting Naber's seam, which seems to be capricious) is the Warrior. This is a good coking coal. Its ash was found to be 3.44, its sulphur 0.84, and its phosphorus 0.017 (in the combustible material as well as the ash). Its specific gravity is assumed to be about 1.29, or like the

*See Note III. at the end.

average of the Black Creek coal given by the State geological survey. From a mean of six measurements of its thickness the latter was taken as 2 feet 2 inches, but it has a higher thin seam separated by a parting of shale varying in extent from a few inches to 17 feet, and as this small seam only reaches about one foot in thickness it has not been considered here, but in some cases will enhance the value of the coal product.

Taking (of the lower seam just mentioned) the above data, there will be found an average of 3,798 tons of this coal per acre of the ground which it underlies.

The "Black Creek" seam, or the first valuable seam immediately above it, averages 2 feet 6 inches in thickness, and has a specific gravity of 1.362. There are, therefore, 217.15 pounds of this coal under every square foot of surface covering it, or 4,728 tons of 2,000 pounds to the acre. This is a most valuable coal for coking, and is the only one which on account of its freedom from impurities is adapted to coke making without previous washing.* An analysis of it given in the State report for 1886, p. 302, shows:

Moisture	1.36
Volatile matter	31.79
Fixed carbon	64.71
Ash	0.82
Sulphur	0.32

Its specific gravity (1.29) as given with this analysis is a little less than my own experiment made it, but this will not very materially alter the figure representing the number of tons to every acre underlain by it. This figure is on my own data 4,728 tons of 2,000 pounds.

The Jefferson seam is the next valuable deposit above the foregoing.

An analysis of it taken from a long exposed heading where its best showing would not be expected, gave me the following results:

	The coal dried at 105° Cent.
Volatile matter	28.73
Fixed carbon	64.57
Ash	6.70
Sulphur	2.82
Phosphorus	0.001

*See Note IV. at the end.

Assuming its specific gravity to be 1.29 and its average thickness as great as the Black Creek coal, this would give to the acre 4,627 tons. There are also two smaller coal seams beneath the main bed, but separated by slates and sandstones of variable thickness and therefore not counted here. It may be assumed, then, that there are 4,627 tons of this coal to each acre which it underlies.

There is a black-band ore which has been discovered in Jefferson county high above the Jefferson seam, but as it has never been successfully worked and as it only reaches about one foot four inches in thickness, it may be disregarded. The important black-band immediately above the Warrior coal bed in the Alabama mines is a most valuable deposit, but very variable in its location, as has previously been said. An analysis of a sample which I selected as a fair average has already been given.

Its specific gravity is 2.31 (mean of 3 determinations), and its average thickness (mean of 5 measurements) is 1.25 feet. It therefore will average 3,924 tons of 2,000 pounds to the acre, but owing to the great change of its position within short distances, it would not be safe to count upon more than half of this as available for economical mining at present.

The Black-band which usually accompanies the Warrior coal bed has not been sufficiently studied in Cullman county to enable one to predict what its quantity and constancy will be. It is likely, however, to become an important factor in any estimation of value.

The black-band ore may be looked for anywhere in the vicinity of the Warrior coal, and may, for aught that is known to the contrary, occur in large quantities, but it is such a variable and fickle deposit that, in the absence of any positive information concerning it in this region, I prefer to omit further mention of it here.

NOTE I.

The system of numbering townships in Alabama is based upon a meridian run through Huntsville (general Coffee's line, which is the ordinate for upper Alabama), and a meridian run through St. Stephen's by general Freeman, which is the ordinate for southern Alabama. The latter finished his work first, and ran an abscissa on a circle of latitude east and west dividing the state into two parts; a northern and a southern. A township is a horizontal slice across the whole state. Coffee established twenty-two townships from the northern boundary of Alabama to Freeman's line, and they are numbered 1, 2, 3, etc.—south. Freeman established twenty-four townships, counting 1, 2, 3, etc.—north from the northern boundary of Florida. The "ranges" are the distances along the northern edge of a township six miles long, and are counted 1, 2, 3, etc., east or west of the meridian from which they are measured. The number of the sections in each of these ranges is begun at the northeastern square mile, and proceeds west to the limit of

the range on the upper tier, descending to the *adjoining* square mile or section on the second tier, and returning back on that tier to the meridian of the starting point, descending here to the adjoining section of the lower tier, and thus zigzagging till the last section of that range is reached at the meridian of starting. These sections are each divided into quarter sections or squares of half a mile on the side, and are called northeast, northwest, southeast or southwest quarter sections of such a section, range, and township.

The above information is from Mr. Wilson, assistant to major Fitzhugh.

NOTE II.

The following is an extract from page 83 of the State geological report for 1886:

"Though the soils of this county are naturally poor for our great staples, cotton and corn, still by frequent light dressings, judiciously applied, of a compost containing lime, they can be made to average two hundred and fifty pounds of lint cotton to the acre, of much better staple than that of more favored regions. They can also be made to yield some twenty-five bushels of corn to the acre. These products, however, are not the crops for the "Hill country of Alabama:" and, the sooner our people find it out, the better it will be for them and the State. This mountain soil, with a little strengthening, as well as the climate, is especially adapted to the raising of fruits, vegetables and grasses, and in proportion as these crops are cultivated, and cotton and corn let alone, will this beautiful and healthy region blossom and bear fruit."

NOTE III.

In the official State geological report for 1886, the section of strata found in the Jefferson mines includes the series of the general section from below the Black Creek seam (No. 14) to No. 18. The Newcastle seam is No. 21, and is therefore not included. This is also made still more clear from the blue print of the region kindly made for me by major Fitzhugh, on which the outcrop of the Newcastle vein is seen to enclose a region entirely to the south of the Warrior, Brake and Jefferson mines.

NOTE IV.

It is in the opinion of the writer a mistake to use the coke made from the Pratt, Newcastle, Jefferson and Warrior seams without previous preparation. Favorable contracts for preparing these coals for coking could be made, which would leave a good profit to the coke manufacturer, while the efficiency of the coke would be thereby raised. By washing, the percentages of ash, phosphorus and sulphur would be reduced, and the product would be made equal in value to Connellsville or Pocahontas coke.

The Black Creek coal seam seems to be the only one which is free enough from these impurities to warrant its use without preparation. These observations are made with deference to the large experience and extensive knowledge of iron making of the iron masters of Alabama, and without such a systematic study of the subject as would be necessary in order to enable the writer to discuss the question on equal terms with them. Nevertheless, the conviction of their general correctness grows stronger with every addition to the writer's store of facts. It would be well to allow the experiment to be tried in a small way in any case.

LAKE SUPERIOR STRATIGRAPHY.

By ANDREW C. LAWSON, Berkeley.

In a recent paper by Prof. Van Hise, entitled "An attempt to harmonize some apparently conflicting views of Lake Superior Stratigraphy,"* a new view is advanced as to the position of the

*Am. Jour. Sci. Vol. XLI, Feb., 1891.

dividing line between Archæan and post-Archæan in the lake Superior region, which seems to me to be fraught with confusion to this branch of geological inquiry and to be based upon an undervaluation of some important conditions which obtain generally in the region. The new information given us by Prof. Van Hise is of the most interesting character and will do much to harmonize some seemingly conflicting views; it is therefore to be regretted that the approximation to harmony which he seeks to establish should be marred by an utterance which is not only out of accord with the very commonly accepted view as to the upper limit of the Archæan, but is in startling discord with the significance of facts which have been well authenticated.

It is with much reluctance that I offer this criticism. For the most part Prof. Van Hise and myself are, or at least have been, in agreement as to the interpretation of the main facts of lake Superior geology which have come under my notice; and if the new view now advanced by him involved simply a matter of expediency or nomenclature I should abstain from adverse criticism, so that our general agreement might not be confounded with a disagreement on a minor point. It appears to me, however, that this new suggestion involves a bad principle which it would be unwise to pass unchallenged. I am constrained, therefore, to ventilate the subject, feeling confident that I shall suffer no condemnation at Prof. Van Hise's hands should I succeed in showing that he has overlooked, or is not cognizant of, considerations which if placed in evidence must logically force him to modify his present judgment.

During the time that I have been at work northwest of lake Superior, no general truth has been brought home to me more impressively than the fact of the individuality, so to speak, of the Archæan complex. By the latter term is meant, in accordance with the usage of nearly all previous writers on this field, the complex of rocks upon the profoundly denuded remains of which the Animikie strata of Thunder bay rest in strongly marked unconformity. It includes all the rocks which existed as geological formations prior to that epoch of denudation which produced the truncation of the pre-palæozoic continent and prepared the floor upon which the Animikie and its equivalents rest. How great was that epoch, how stupendous is the evidence of its duration, and how important it is as a geological base line I have attempted

to show in a former paper.* In that complex there are recognizable, in the region which I have examined, at least two great groups of stratified rocks, the Coutchiching and Keewatin, with a probable unconformity between them. This unconformity is inferred not from incongruity or discordance of structural planes but from the sharp contrast in the lithology of the respective formations as indicating a change in the condition of rock formation, and from the presence of conglomerates near the base of the Keewatin as indicating a period of erosion. These two groups of strata have been folded and welded together by the same crust-crumpling forces and both bear identically the same relations to the great batholites of Laurentian gneiss and granite. That relation as I have elsewhere attempted to make clear is one which has arisen from the irruption through crustal rocks of a sub-crustal granitic magma. At the time when this irruption transpired the Coutchiching and Keewatin rocks co-existed forming the lower part of the crust, and they were together pierced and invaded by the common sub-crustal magma. The evidence which establishes this proposition is explicit and has been set forth in detail. It is this great and incontrovertible fact of the simultaneous invasion of both Coutchiching and Keewatin by the magma now recognizable as Laurentian foliated granite, which knits the complex together and gives it an individuality and totality unique in structural geology. Briefly then we have these considerations before us:

1. In their relations to the complex as a whole and to the Laurentian granites and gneisses which bind the complex together as a matrix, the Coutchiching and Keewatin are entirely similar.

2. Both were firm brittle rock formations at the time when the Laurentian batholites were undifferentiated molten magma, hence by the criterion whereby the age of rocks in a geological sense is usually determined both are of younger age than the Laurentian which invaded them as irruptive masses.

3. The whole complex, constituted as above sketched, antedates the great pre-palæozoic hiatus or erosion interval which is probably the greatest in American geology.

4. The above three statements are arrived at practically independently of any considerations as to the lithology or original character of the strata of either Coutchiching or Keewatin.

*Note on the pre-palæozoic surface of the Archæan terranes of Canada. Bull. Geol. Soc. Am. Vol. I, pp. 163–174.

It would seem, therefore, in view of these considerations that the last thing which the geological taxonomist would attempt, would be to separate one of these groups from the complex and say, "It is post-Archæan," and of the other, "It is Archæan." Yet this is what Prof. Van Hise, by some unaccountable misconception of the reality of things, proposes to do. He draws the line between Archæan and post-Archæan at the summit of the Coutchiching. One phase of the confusion which arises from such a step is apparent from a glance at the table at the end of his paper. For, the Keewatin being placed as post-Archæan, we have this undesirable incongruity presented to us of the Laurentian rocks which are irruptive through it designated under an older period. If the Keewatin is post-Archæan the Laurentian is *a fortiori* so. The old idea of the Laurentian of the lake Superior region being a pre-existent basement upon which the Keewatin and Coutchiching have been deposited surely does not linger in Prof. Van Hise's mind?

In seeking the reasons for Prof. Van Hise's suggestion to call one member of this great fundamental complex Archæan and another post-Archæan, or at least the influences which led him to it, I find two fairly distinct propositions which form to a large extent the basis of his argument. One is that contained in the opening paragraph of his paper and constituting an important factor in his classificating scheme, viz., that the plane which forms the upper limit of the Coutchiching is a plane separating a granite-schist complex from an upper clastic series. This is an erroneous idea. The plane in question has not the significance ascribed to it. The granite-schist complex exists on both sides of this plane without any question whatever. The proposition further seems to imply that there *is* a granite-schist complex of which the schist constituent is different in its origin from the schists on the upper side of the plane. An hypothesis of that character should not, it seems to me, enter into a classification of geological formations or groups of formations. The fact that the original character of certain schists of the Archæan is not fully demonstrated by the published evidence should not warrant their being separately classified as schists or "crystalline schists" par-excellence. Such a usage of terms carries with it the implication that there are no crystalline schists in the "overlying clastics," while as a matter of fact not only are crystalline schists abundant in the Keewatin,

but in other regions fossiliferous strata are known which are not a whit less "crystalline schists" than the Coutchiching rocks. In my judgment there is no portion of the Archæan to which the term crystalline schists can be appropriately applied to the exclusion of the other parts. There are true crystalline schists in all parts of that complex. The term "schist-granite-gneiss complex" which Prof. Van Hise uses to describe the Archæan is appropriate and is graphically expressive of the salient features of the Archæan. The error which he falls into is in not recognizing that the Keewatin is part and parcel of that "schist-granite-gneiss complex." The second proposition which Prof. Van Hise uses as a basis of argument is that the physical break which he describes between his Upper and Lower Vermilion is the equivalent of the break between the Animikie and Keewatin. That also is an erroneous idea. I have little or no doubt of the reality of the break which Prof. Van Hise describes not only in Minnesota but elsewhere. I have been cognizant of evidence of such a break since the summer of 1889 which I spent in the Hunter's Island country. I interpret the unconformity in Ontario and Minnesota, however, very differently from Prof. Van Hise. The position assigned to this break by Prof. Van Hise leads him to correlate the "Upper Vermilion" fragmental rocks and those at Kamministiquia with the Animikie. A study of the stratigraphy of the region has demonstrated to me that such a correlation contradicts the facts. At Gunflint lake, on the International Boundary, the Animikie rests on the Archæan, here composed of a complex of Laurentian granite-gneiss and Keewatin schists, in pronounced unconformity. The Archæan schist-granite-gneiss complex was profoundly denuded before the deposition of the Animikie which lies in almost undisturbed attitudes on its truncated edges. This unconformity has often been described and never questioned. Now, the same Laurentian granite has been traced by me in well bared, continuous exposures from Gunflint lake for 15 miles to the north side of Saganaga lake where it is again seen bursting through the Keewatin schists with abundant and clearly observable evidence of irruption. Included in the Keewatin rocks are the "Upper Vermilion" fragmental rocks or Ogishke conglomerates with their associated grits and slates. The conglomerates come directly against the granite and the latter is irruptive through the whole. Thus the Ogishke conglomerate is older than the Saga-

naga granite upon which the Animikie rests unconformably. In other words the break which Prof. Van Hise describes is within the Keewatin group and would seem simply to divide that group into an upper and lower series. Corroborative evidence of this is seen on following the clastic slates which accompany the Ogishke conglomerate, through to Basswood lake. There they are seen in contact with the Basswood area of Laurentian granite-gneiss and the contact is again irruptive. These observations are given in advance of a geological report on the Hunter's Island region which I have in preparation but which may be delayed somewhat in publication. Other arguments might be advanced but I have, I think, given sufficient to demolish the correlation of the Ogishke or "Upper Vermilion" with the Animikie.

As to the Kaministiquia rocks I have simply to say that Prof. Van Hise's visit to that district must have been very hurried or he would have observed that the same fragmental rocks which he refers to, come out close to the shores of Thunder bay and form the basement upon which the undisturbed Animikie rocks rest with the same strongly marked unconformity as that exhibited at Gunflint lake. They are here intimately and apparently inseparably involved with other Keewatin rocks and the whole group is again invaded by Laurentian granite so that there is no possibility of correlating these rocks with the Animikie. With reference to the Huronian of lake Huron I have long been of the opinion that there were probably two groups of rocks included under that designation. As to the geological position of these Huronian rocks I have always been in very much doubt and am as far to-day from any settled opinion on that point as I was when I first looked into the question. The earliest descriptions of Huronian and the investigations of Irving go a long way to show that some of these rocks are the equivalent of Animikie. The original observations of Murray and the more recent ones of Barlow* indicate that there is a portion which bears the same relation to the Laurentian as does the Coutchiching and Keewatin. On this latter point the evidence is more explicit and satisfactory to my mind than that favoring the correlation with the Animikie. The unsettled condition of the Huronian question is a great hindrance to the progress of clear and correct ideas in an extensive field of geological research.

*On the contact of the Huronian and Laurentian rocks north of Lake Huron. AM. GEOLOGIST, July, 1890, Vol. VI, No. 1.

A critical re-examination of the region north of lake Huron is almost absolutely necessary to further satisfactory progress. It has occurred to me that it might not be out of place for the International Congress of Geologists at its coming session to take cognizance of this necessity and nominate a commission to prosecute the investigation of the field. The problem might be regarded as an international one, the field being along the boundary and the interest equal on both sides, so that the commission might act in harmony with the United States and Canadian geological surveys.

Prof. Van Hise finds as a result of his present classification of the lake Superior geological groups no use for the term Ontarian which I suggested some time ago as a useful if not necessary one to include the different rock groups of the upper Archæan. That classification being shown to be untenable the necessity for such a comprehensive term appears all the stronger from a consideration of Prof. Van Hise's table. There he places an irruptive unconformity between the Laurentian and the Coutchiching. This irruptive unconformity occurs between the Laurentian and the *system* of strata of which the Coutchiching and Keewatin are constituent groups. This system comprising two, and possibly more, groups, seems to me to require a name, the necessity being even greater than the need of Algonkian to include Animikie and Keweenawan.

As a substitute for Prof. Van Hise's table of classification I offer the following for the region northwest of lake Superior:

PALÆOZOIC.	ALGONKIAN SYSTEM.	Keweenawan or Nipigon Group.	
		Unconformity.	
		Animikie Group. (Possibly Huronian.)	

Unconformity—Greatest erosion interval in American Geology.

<table>
<tr><td rowspan="7">ARCH-
ÆAN.</td><td rowspan="5">ONTARIAN
SYSTEM.</td><td rowspan="3">Keewatin Group.
(Possibly Huronian.)</td><td>Upper Series.</td></tr>
<tr><td>Van Hise's Break.</td></tr>
<tr><td>Lower Series.</td></tr>
<tr><td>Unconformity?</td><td></td></tr>
<tr><td>Couchiching Group.</td><td></td></tr>
<tr><td>IRRUPTIVE UN-
CONFORMITY.</td><td></td><td></td></tr>
<tr><td>LAURENTIAN
SYSTEM.</td><td></td><td></td></tr>
</table>

Note.—While writing on this subject it may be well for me to state that the late Prof. Alexander Winchell was in error in supposing, as appears on page 218 of his recent paper, "American opinion on the older rocks," that I ever regarded the Animikie and Keweenawan as part of the Archæan. I have never entertained that idea for a moment and have been entirely misunderstood on this point by my late lamented friend and fellow worker in lake Superior geology. A. C. L.

ON MELANOPHLOGITE.*

By A. STRENG, Giessen.

In the twenty-seventh volume of the *Oberhess Ges. für Nat. u. Heilkunde*, p. 123, I have offered some observations on melanophlogite in which I announced that the material at my command contained no SO_3 but sulphur in a different combination. Recently different works by Pisani and especially by G. Friedel (Sohn) in which a content of SO_3 is announced as certain, aroused in me some doubt as to the correctness of my results, and especially it appeared to me as possible that my specimen may not have been a true melanophlogite but a pseudomorph of melanophlogite after quartz or opal. After more extended examination I have discovered however that this doubt was not justified; for I found in the same material in which I had been unable to find any SO_3 in solution in HFl, 3.82 per cent of SO_3 in a decomposition in $NaCO_3$. Nevertheless I repeated my efforts with every conceivable precaution and variation, to show the presence of SO_3 in the fluoric acid solution, but without reaching any other result.

As it was so well established that my sulphur-bearing melanophlogite contained no SO_3, I knew the sulphur present in it was in some other combination.

If now melanophlogite contains, in the indicated absence of a

*Translated from the 28th *Ber. d. Oberh. Ges. f. Natur. u. Heilk.*

corresponding union with metals, sulphur in the form of sulphide of silicon, then, in the treatment with HFl during the solution of the SiO_2, the SiS_2 must on becoming free, combine with H_2O to form SiO_2 and H_2S. In fact, when a half grain of the material already examined, a mixture of melanophlogite crystals of a specific gravity 2,044 with pulverized opal, was overflowed with HFl in a platinum dish, H_2S was produced, which made itself apparent as such not only by the odor but also by the reaction with lead-paper. This is, in my judgment, a characteristic reaction for the presence of SiS_2, for it appeared also in red heat, as in the destruction of organic substance. Still one might be in doubt whether there is a mechanical mixture or a chemical union. The noticeable constancy of the composition in all analyses hitherto made indicates a chemical union. If we take the mean of all the analyses hitherto, that is $SiO_2=91.69$ and $SO_3=5.85$, as foundation, we can from them calculate the formula $SiS_2+42SiO_2$ ($Si_{43}O_{84}S_2$). From Friedel's formula, $SO_3+20SiO_2$, is derived in like manner the formula $SiS_2+39SiO_2$.

If it be desired to determine the sulphur directly, dissolve silver-oxide in excess of hydrofluoric acid, and after adding some water to the pulverized melanophlogite treat it with this liquid until the mineral has entirely disappeared. The result is a black precipitate of Ag_2S which can be filtered out and analyzed. In this manner I obtained from 0.4993 grains of melanophlogite, of a specific gravity of 2.044, 0.071 grains of Ag_2S, corresponding to 1.84 per cent. of sulphur (or 4.5 per cent. of SO_3), whereas I had before obtained 3.82 per cent. of SO_3 from the solution with Na_2CO_3. This number was then somewhat too low. After red heat I obtained with the silver solution 1.28 of S (3.2 per cent. of SO_3). With the same solution of AgFl in HFl I obtained from very thin scales of melanophlogite on crystals of sulphur 0.58 per cent. S in the test with silver solution, and in the decomposition with saltpeter and soda I obtained 0.56 per cent. of S.

As to how the variation in density of melanophlogite, as pointed out by me, may be explained, I cannot yet state, owing to insufficiency of material, as well as the question of pseudomorphs. On the other hand it appears to me possible that the acquiring of a black color in the presence of heat can be attributed to the formation of iron-sulphide, as melanophlogite always contains some iron.

Giessen, March 3, 1891.

EDITORIAL COMMENT.

THE OLDEST FISH REMAINS KNOWN. — The most important announcement of palæontological discovery during the past season is that recently made by Mr. C. D. Walcott of the U. S. Geological Survey of the occurrence of fish-remains in the Lower Silurian rocks of Colorado. The Silurians of Herefordshire and Shropshire in England have long been known to contain abundant relics of the early vertebrates, but these remained for many years the only recognized traces of this subkingdom below the Devonian strata, for though similar discoveries were reported from Bohemia and the Hartz, yet as the accompaniments of these indicated Devonian rather than Silurian date they have been regarded as of later age, especially as the fossils belonged to genera considered in England to characterize the Devonian rather than the Silurian strata. (*Asterolepis*, *Coccosteus and Ctenacanthus.*)

The island of Œsel in the Baltic sea is thus far the only European station outside of the British Isles which has yielded indications of a Silurian fish-fauna. These were of an affinity and in associations which confirmed the inferences from the English specimens as to the nature of the earliest vertebrate life. They were in both cases of the same type and consisted of simple shields of one or more pieces covering the dorsal and perhaps also the ventral surfaces of the animal. The fossils belong to the genera, *Cyathaspis* and *Scaphaspis*, if indeed these were not parts of the same species.

In 1885 similar remains were found by Dr. E. W. Claypole in the Onondaga rocks of Perry Co., Pa., on a horizon a little lower than the Lower Ludlow of England from which the oldest specimens there found had been obtained. These form the genus *Palæaspis*. He also announced a spine (*Onchus pennsylvanicus*) from the Clinton beds indicating the existence of elasmobranch fish at a yet earlier date.

In 1888 Mr. Matthew discovered in strata referred to the Lower Helderberg in New Brunswick remains of a similar nature indicating the existence of fish in the seas of that region in Silurian time. His species is *Diplaspis acadica*.

The last find which has called out this note was made as said above by Mr. Walcott in a collection of fossils found near Cañon

City, Colorado, by Mr. T. W. Stanton. The find was so surprising that a second collection was made from the same place and as it confirmed the previous deduction Mr. Walcott himself went out to the spot in December last and on examination found that the bed from which the remains had been obtained lay about 180 feet below others containing well characterized invertebrates of Trenton age. He therefore concludes that the existence of fish in the Trenton series is established.

It is worthy of note that Mr. Walcott's fossils indicate the presence of elasmobranchs as well as of placoderms and in that respect confirm previous observations. Should his suspected demonstration of notochordal relics among his fossils prove correct it must remove all doubt regarding the vertebrate nature of these earliest known fish.

It now remains for some one to discover the ancestors of these Trenton fish in rocks of older date for it is not possible to believe that they were the primeval vertebrates.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Petrography and Structure of the Piedmont Plateau in Maryland. By GEORGE HUNTINGTON WILLIAMS, of Johns Hopkins University. With a supplement on *A geological section across the Piedmont Plateau in Maryland.* By CHARLES R. KEYES. Bulletin, G. S. A., vol. ii, pp. 301–318, with a plate map, and two sections in the text; and pp. 319–322, with three figures in the text; March 15, 1891. The rocks of the western part of the Piedmont area in Maryland are semi-crystalline, consisting of phyllites, sandstone, and marble, with very scanty eruptive rocks, the last being represented only by Mesozoic diabase or by serpentine whose origin is still in doubt. The eastern part of the area is strongly contrasted with the foregoing, as it consists of highly crystalline rocks, including sedimentary gneisses, quartzites, and dolomite, and eruptive rocks of very great variety and abundance.

Professor Wiliams writes; "Rocks whose eruptive origin is either undoubted or most probable cover at least half of the now exposed surface within the eastern or more crystalline area. A much less proportion can be assigned with any degree of probability to sedimentary formations, while the remainder possess the characters of both classes to such a degree that their origin must still be considered as undecided." In many places the eruptives "have suffered hardly less complete foliation and metamorphism than the sediments which surround them, while in both this action is far in excess of what has taken place in any portion of the western area."

Sections crossing the Piedmont plateau show throughout very steep or vertical or overturned dips; and it is believed that they comprise many sharp folds and faults. The most probable hypothesis of the structure of this area in Maryland, according to Prof. Williams, supposes that the eastern rocks are far more ancient than the western and extend beneath the latter, forming the floor on which they were deposited; and that this crystalline floor, previously much folded and metamorphosed, underwent at least one more folding after the western schists had been laid down, the latter then acquiring their cleavage and partial metamorhism.

The section studied and described by Mr. Keyes extends from Catoctin mountain southeastward across Sugarloaf mountain and onward to Washington. It includes the fossiliferous Frederick limestone, which is referred to the Trenton period.

Electro-Chemical Analysis. By EDGAR F. SMITH, 12mo., 116 pp. Philadelphia, P. Blakiston, Son & Co., 1890.

This little volume will be useful to those students and others who wish to become acquainted with the methods of quantitive analysis by electrolysis, which are generally omitted from the larger text books. It contains also a historical review of the introduction of the electric current into chemical analysis.

Geological Survey of Kentucky. Report on the geology of Whiteley county and part of Pulaski. With plates and other illustrations, 44 pp. Roy. oct., and a geological map. By A. R. CRANDALL. This is one of those admirable county reports for which the Kentucky survey is well known. The geology of the county embraces a range from the Coal Measures to the Devonian; and covers a belt which is well known for its bold topographic features and contrasts, from Ohio to Tennessee. In the southeastern part of the county the geology and topography are varied by the Pine mountain fault, which runs northeastwardly and which causes the exposure of the lower members of the Devonian in the midst of an area of the Coal Measures. The report gives the details of the stratigraphy involving the separate beds of coal, and is finely illustrated by several plates of reproduced photographs of important topographic and scenic landscapes.

There is, however, one defect which we note in this report, one which we have noticed in several of the Kentucky reports—*it has no date.* From cover to cover there is no evidence to show what year in the administration of Prof. Proctor the report was published.

Geological Survey of Kentucky. Report on the geology of Clinton county, with a map. By R. H. LOUGHRIDGE, pp. 48, Roy. octavo. Submitted Feb., 1890. This county ranges from the lower Coal Measures to the Cambrian (Hudson River), descending from the southeast toward the northwest. Poplar mountain, and some hills further west, constitute the extreme western limit of the Cumberland mountains within Kentucky. The author gives various local sections and some chemical analyses of coals. Oil and gas have been known in the county for sev-

enty years. Borings made for salt water were annoyed by the outflow of gas and oil at a depth of about 200 feet, but these substances have never been brought into economic notice. The report gives also the results of an examination into the soils, both chemical and mechanical.

CORRESPONDENCE.

Excursion Across Long Island. Having spent a vacation of four weeks last summer at Eastport, L. I., N. Y., near the centre of the island, an opportunity was afforded of renewing my study of the drift phenomena on that wonderful little isle by the gate of the sea. During my stay, at Eastport I made an excursion across the island to Wading River. A walk of about three miles brought me to the so-called "Backbone" supposed to mark the terminal front of part of the great continental ice-sheet, or Laurentide glacier. The boulders begin to be quite plentiful and the glacial till is easily recognized.

After leaving Manor however, the boulders begin to disappear and few are seen in crossing the Riverhead valley—an old subglacial river channel—until Wading River is reached and where the northern series of hills rise along the sound. Here again the erratics are met with in abundance and are much larger than those seen along the line of the terminal moraine at Manor. I had been inclined to believe that geologists were in error in supposing that these two moraines represented two separate Glacial epochs, as I never could see any evidence of more than one, but this trip across the island tended to shake my faith in the one glacial movement, for if one ice-sheet covered the whole island at the same time, how is it that no boulders are found in the intervening valley?

At first I was sorely puzzled. Another problem presented itself. I saw that the boulders at Wading River far exceeded in size any we had noticed along the southern ridge and it occurred to me that this was proof of two distinct ice-sheets, for one glacier would not be likely to drop all of the large erratics on the north side of the island.

A subsequent visit to Rock hill, however, cleared away some of those doubts, for there on the very summit of the southern ridge, or backbone as it is called, was an immense boulder similar to those at Wading River. The natives have been quarrying from it for the past hundred years or so, and yet this erratic from which the hill derives its name, is more than fifty feet in circumference and about twenty feet in hight for it stands up among the pines like a huge monument, or obelisk, in the desert. It is very impressive. It looks as if it might have been dropped by floating ice, but it would be strange if floating ice would drop its burden directly on the summit of the terminal moraine; besides this huge erratic lies directly in the path of the glacier on its "march to the sea." It is a coarse gneissic granite and must have been torn from the same parent rock as those of the same kind seen at Wading River.

I am more than ever convinced that the two series of ridges belong to one and the same Glacial epoch. The absence of boulders in the valley can be explained, I think, in this way, that a glacier partakes very much of the character of the ground over which it passes, and really the surface part of the island is a *cast*, so to speak, of the mainland. Portions of the ice-sheet were freighted with boulders and parts of it were not. In general, of course, the erratics become smaller to the south, and this system, for it is a system, of moraines and boulderless valleys or depressions, may go far to account for the so-called "fringe." The true terminal moraine has yet to be defined.

Louisville, Ky., March 23, 1891. JOHN BRYSON.

CRETACEOUS AND TERTIARY STRATA NEAR WILMINGTON, N. C.* American geological literature contains many references to the Eocene beds of Wilmington, N. C. and the Cape Fear river region and to the occurrence of Cretaceous fossils in them. This commingling of Cretaceous and Tertiary forms has been denied by some authors and of those who accepted the fact some have held that the species were actually contemporaneous, others that they were mechanically mixed by the breaking down of fossiliferous Cretaceous strata during Eocene time. Dr. W. B. Clark who has published† the latest observations on these deposits, gives positive proof of the commingling of faunas and states his belief that they were mechanically mixed.

During a recent visit to that region the writer found the probable source of the Cretaceous forms in a bed of highly fossiliferous siliceous limestone of Cretaceous age which lies immediately beneath the zone of Tertiary phosphatic conglomerate in which the commingling occurs. The Tertiary section varies from point to point and is never more than a few feet thick. At Castle Haynes, 10 miles north of Wilmington, and at Rocky Point, 20 miles north, it may be described as follows:

1. White limestone with many Tertiary and perhaps a few Cretaceous fossils .... 2 to 4 ft.
2. Conglomerate of greenish phosphatic pebbles, usually cemented with lime, in some places imbedded in sandy clay. Sharks' teeth and Tertiary molluscs and corals are numerous. Cretaceous fossils also occur. Thickness .... 2 to 6 ft.
3. Gray siliceous limestone full of Cretaceous fossils. Thickness undetermined.

This last named layer is exposed in the bank of the creek at Castle Haynes and a considerable quantity of it has been quarried from beneath the conglomerate in the phosphate pits at the same place. It has also been found in the deeper pits at Rocky Point, though at the time of my visit it was covered with water. There were many fragments of it lying on the dumps there, some of them with the phosphatic conglomerate attached to one side. It is possible that some of the Cretaceous species that have been enumerated by various authors as coming from the Eocene were really taken from this lowest stratum and mixed on the dump, as no previous writer has mentioned the existence of this Cretaceous bed though several have stated that the Tertiary rests on the greensand marl.

*Published by permission of the Director of the U. S. Geological Survey.
†Bull. Geol. Soc. Am. Vol. I, pp. 537-539.

Among the fossils of No. 3 are such well known Cretaceous forms as:

Cardium eufaulense Con.	Pachycardium spillmani Con.
Exogyra costata Say.	Ostrea subspatulata L. & S.
Aphrodina tippana Con.	Crassatella pteropsis Con.
Cucullæa antrosa Mort.	Trigonia divaricata Tuomey=T. angulicosta Gabb.

Most of these forms are very numerous and there are several others not fully identified, but none of the Tertiary forms so abundant in the overlying beds are found in No. 3.

The existence of a highly fossiliferous Cretaceous stratum in contact with the Tertiary was the one fact needed to complete the explanation of a mechanical mingling of the faunas and it is, therefore, deemed worthy of publication.

U. S. Geological Survey, T. W. STANTON.
Washington, D. C., April 9, 1891.

PERSONAL AND SCIENTIFIC NEWS.

AN AUSTRALIAN SAMPLE OF GOLD has analyzed as high as 99 per cent. gold and the remainder silver, with iron and copper. Again, a sample of gold from Transylvania contained as high as over 38 per cent. of silver. But the average purity of the gold found all over the world is about 85 parts gold and the remainder silver, with iron and copper in greater or less quantities, together with traces of the rarer metals. The average fineness of California gold is about 88 per cent. of gold. The average of Australia is about 92 per cent. Of the best grade of Nova Scotia 97 per cent. Of Chili, the average is about 82 per cent. Of Russia, 93 per cent. And thus all gold found in any country, has so far shown by actual analysis, that it contains more or less silver intermixed with it as an alloy in various proportions, and also nearly always is found contaminated with iron and copper, and sometimes with traces and even appreciable amounts of palladium, rhodium, osmium, iridium, etc.—*Dr. Willis E. Everette.*

THE LEGISLATURE OF TEXAS, WHICH HAS JUST ADJOURNED provided for the continuance of the geological survey by appropriating the sum of $35,000.00 per annum for the next two years.

In addition to this amount the printing is provided for in the appropriation for public printing, and sums were allowed for the testing of the lignites and preparation of a state map, which will very much increase the total available funds of the survey. The salary limit was also increased five hundred dollars each for the state geologist and three assistants and provisions made for a good suite of rooms for the chemical work of the survey in the new laboratory building to be erected at the University of Texas.

THE LEGISLATURE OF MINNESOTA HAS ALSO AIDED the state geological survey by appropriating $15,000 for the next two years for work in the field and for apparatus in the laboratory. This is in addition to the proceeds from the Salt Spring lands which in the past have supported the survey. The survey reports

are printed as state documents, under standing law, and the cost thereof is not chargeable to the survey funds.

This legislature also established a School of Mines at the State university, appropriating $6,000 for that purpose, and $4,500 per year for its maintenance.

IN CALIFORNIA $50,000 have been appropriated by the Legislature for the support of the State Mining Bureau for the next two years, this being just one-half the amount appropriated by the preceding Legislature for the same length of time. This includes the cost of printing its report.

MR. CHARLES R. KEYES HAS BEEN APPOINTED palæontologist of the Missouri geological survey.

THROUGH THE INSTRUMENTALITY OF CHAPLAIN JOHN D. PARKER of the U. S. Army, while stationed at Fort Robinson, Neb., initial efforts were made in the fall of 1890 for the organization of the Nebraska Academy of Sciences. A largely attended meeting was held Jan. 1, 1891, at Lincoln which resulted in a permanent organization, with Dr. J. S. Kingsley, of the Nebraska State University, as president, and Prof. W. E. Taylor, of Peru, as secretary. The first publication of the Academy contains the constitution and plan of organization. Chaplain Parker was largely instrumental in originating the Kansas Academy of Sciences, as well as the Kansas City Academy of Sciences.

DISCOVERY OF MASTODON REMAINS IN THE SHENANDOAH VALLEY, VIRGINIA. While excavating a boggy depression for the purpose of making a fish-pond on the land of Mr. Frank, near Edom, Rockingham Co., the bones of a mastodon were discovered which, according to Dr. Zirkle, will make an almost complete skeleton. The latter gentleman has secured the remains and will present them to the National Museum.

THE GAP NICKEL MINE. This mine situated near Gap Station, Lancaster Co., Pa., and the source of most of the nickel used in this country is about to shut down, in fact work is now practically suspended, only a few miners being at work in prospecting for new bodies of ore, and, from all appearances, with little probability of success. The ore has gradually been thinning out for several years. The history of this mine is remarkable. For many years it was worked for copper, the nickeliferous pyrrhotite being thrown away as worthless until the year 1853, when its value was discovered. The vein is vertical and varies from four to thirty-five feet in width. Paying ore about fifty feet from surface; the gauge is mica schist and hornblende; formation Lower Silurian limestone.

PROF. JAMES GEIKIE, OF EDINBURGH, gave during March and the early part of April a series of ten lectures in Boston, under the auspices of the Lowell Institute, his theme being "Europe during and after the Ice Age." Among many important matters brought out in these lectures supplementing this author's well known works on the "Great Ice Age" and "Prehistoric Europe,"

perhaps the one of greatest interest relates to the extent of the ice-sheets of the British Isles and continental Europe during the latest Glacial epoch. Professor Geikie recognizes certainly two and probably three or more epochs of glaciation, between which the ice was melted away and as genial climate prevailed as now. Whereas at the time of maximum glaciation, the British ice-sheet reached south to the vicinity of London, its latest extension was only to Lincolnshire; but Scotland was wholly ice-covered during both of these epochs, excepting only its highest mountain peaks. A map of the latest Scandinavian ice-sheet was displayed, representing Norway and Sweden as enveloped by ice, excepting a considerable part of Gothland in southern Sweden. Eastward this ice-sheet appears to have extended to the White sea and to the northwestern borders of lakes Onega and Ladoga and of the gulfs of Finland and of Riga; while a hook-shaped broad lobe, called the "great Baltic glacier," occupied the area of the Baltic sea, extending south into northern Germany and west over about half of Denmark. Well defined moraines on the extreme borders of the glacial drift in Europe are rare, as they are likewise in the Mississippi basin of the United States; but in both countries the more limited region of the last glaciation is bounded by moraines, some of which have been traced in Great Britain by the late Prof. H. C. Lewis, and in Germany by Prof. R. D. Salisbury, both being observers who had examined portions of the terminal moraines of the United States before going to Europe.

In the closing lecture the causes of the Glacial period were considered. Prof. Geikie believes that the astronomic theory of the late Dr. Croll, referring the glacial climate to eccentricity of the earth's orbit, with accompanying favorable geographic conditions, is more probable than the explanation that was advanced long ago by Lyell and Dana and has been urged anew recently by Upham and LeConte, ascribing the ice accumulation to great elevation of the land and changes in the course of oceanic currents. According to the former theory the Ice age terminated about 80,000 years ago. The latter theory, however, is capable of accounting for the late glaciation of the northern United States, which, according to the careful estimates of N. H. Winchell, Andrews, Gilbert, and Wright, from the amount and rate of postglacial erosion in different and widely separated localities, was only brought to an end some 7,000 to 10,000 years ago; or indeed it can equally account for the still more recent glaciation of the Sierra Nevada and other Cordilleran ranges, which Russell and Becker believe to have occurred much nearer to our own times. Professor Geikie entirely distrusts these estimates of the length of postglacial time; and the formerly great altitude of both North America and Europe, which is proved by fiords and by river valleys now submerged 2,000 to 3,000 feet beneath the sea, he would refer to geologic periods previous to the Ice age.

THE

AMERICAN GEOLOGIST

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PETROGRAPHICAL TABLES.

ALFRED C. LANE, Houghton, Mich.

The two tables that are given herewith are for the use of the students of the Michigan Mining School. I have asked for their publication in the GEOLOGIST, not only because they may be useful to its readers, but because in tables of the kind errors are liable to creep in, in spite of all feasible care. I hope for corrections and suggestions, and shall be obliged to those who send me them. I will try to acquaint them with the corrections of others.

1. The first table is to enable tyros to quickly recognize the minerals of a rock section with a good degree of probability. It is based on Lévy and Lacroix's tables and contains the substance of them with slight additions and corrections. The minerals are arranged according to their optical properties. These are generally well defined. As in other such tables there may at times be doubt between alternatives, where we must impale our mineral on both horns of the dilemma.

In dividing minerals according to the index of refraction I have thrown them into three groups according as they have practically the same refraction as Canada Balsam and no relief, or are more in relief yet do not ordinarily appear rough in surface, or are commonly rough in surface ("rünzelig chaginirt"). One can always, I think, throw out one of these three groups in studying a given

mineral. The only minerals that I think of where the double refraction, *i. e.* difference of refraction, is so great that it is plainly perceptible without using both nicols are the carbonates (for which it is characteristic), and talc and sericite, where it may be complicated with pleochroism.

The double refraction is of course indicated by the highest of Newton's colors that the mineral gives. If there is any quantity of the mineral in the section, and of a known mineral, as quartz, with which to compare it, the double refraction can be determined to about ten per cent. of accuracy. For the retardation corresponding to the highest color on Newton's scale given by the unknown mineral, is to the retardation corresponding to the highest color given by the known, as the double refraction of the former is to that of the latter (*i. e.*, .009 for quartz).

The classification by double refraction is rather arbitrary. I have tried to have as few minerals as may be on the border lines, and to have the groups broad enough so that one can really determine in which a given mineral belongs. Yet here, too, it is generally best, if by its double refraction you think that it belongs in one group, to consider adjacent groups as also possible.

Most minerals have an extension,—either perpendicular to the best cleavage, if there is but one, or if there is more than one, equally good or nearly so, in a zone,—parallel to their intersection.

This direction of extension is generally easily recognized. It is almost always near the same direction of light vibration, whether that be the one corresponding to the greatest refraction ($\mathfrak{c}$) called +, or the other called −. In quadratic and hexagonal minerals the extension and an extinction will be in the same direction, and in rhombic and many pseudo-quadratic or hexagonal minerals it is practically so. Such are placed in the columns +ex. O or −ex. O as the case may be. Rarely the extension is in the direction of the mean index of refraction, so that the extinction in that direction is sometimes direction of greatest index of refraction sometimes of least. Then it comes in the column ±ex. O.

If the extinction lies always within 45° of, but not always coinciding with, the + extinction, it is put down as +ex. not O, and similarly with −ex. not O, and ±ex. not O. After each mineral is given the extinction angle, if any, then $\mathfrak{b}$ the middle index of refraction, then as a numerator 2V and denominator $\mathfrak{c}-\mathfrak{a}$.

In uniaxial minerals $2\mathfrak{V}=O$, *i. e.*, $\mathfrak{b}=\mathfrak{c}$ or $\mathfrak{a}$, and the double refraction is written directly preceded by the sign of the mineral, which is at the same time that of (e—o).

When the dispersion of the optic axes is strong that is noted; $\mathfrak{R}<\mathfrak{V}$ means, for example, that the hyperbolas are bluish toward the center. If the mineral is colored that is also noted, and some other briefly put characters. But it should not for a moment be forgotten that such tables serve merely for probable recognition. Not only are there many yet undescribed minerals, but the properties vary through isomorphic or morphotropic groups, and in some cases optical diagnosis will not serve to distinguish well known and defined minerals (e.g.), zircon and cassiterite. It ordinarily suffices, however, for the common minerals. (The difficult and not very common group of zeolites are bracketed.)

2. The second table illustrates Rosenbusch's classification of the igneous (massive "massige") rocks, and is founded on his last edition. The rocks are arranged as far as practicable in horizontal rows according to like mineral composition. Like structures, and names when confined to a determined structure, are in vertical columns.

I have thought it best to add numerous references to page and line. Each page is supposed to have forty lines, and the line is added as a decimal to the number referring to a page. The table may be taken, then, as an analytical index to Rosenbusch's second volume. For the benefit of those who know neither the author nor the book, it should be added that he regards petrographic classification as in a transition stage, and has purposely omitted to make any general table himself. I do not know if one is forthcoming in his shorter petrography. The classification is not exactly in the order given by the book, although it finds its justification there, nor will it be accepted by him as anything final. It may, however, also be useful as a guide to the present use of rock names by those who follow the book, to those who do not read German fluently. Lévy's critique and tables have already been referred to in this magazine. In the table some constituents whose names are embodied in that of the rock are printed in italics and not repeated.

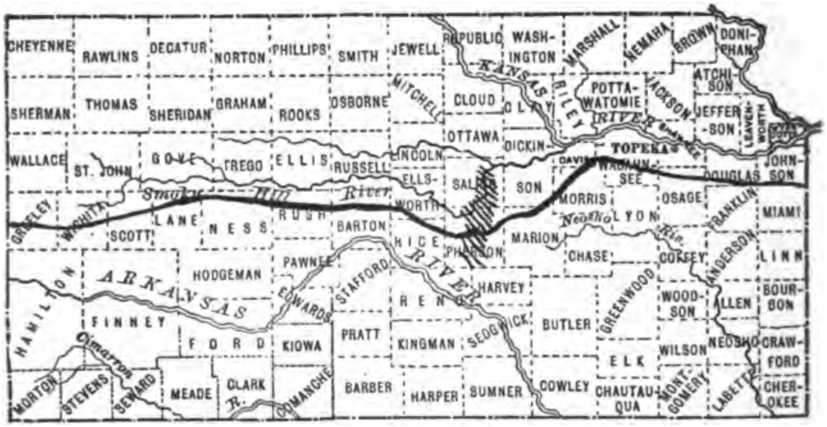
My obligations to Doctors H. B. Patton and L. L. Hubbard for suggestions and help in proof-reading are great.

Houghton, Dec., 1890.

MEGALONYX-BEDS IN KANSAS.

J. A. Udden, Rock Island, Ill.

Over parts of the western plains there are found deposits consisting of gravels, sand, volcanic dust, and loam, which have been regarded by some as belonging to the Quaternary age, and by others as belonging to the Pleiocene.* Having some time ago found such deposits in the central part of Kansas, and having observed some features in them that may be of interest, I venture to offer the following notes on their occurrence in McPherson county, Kansas.

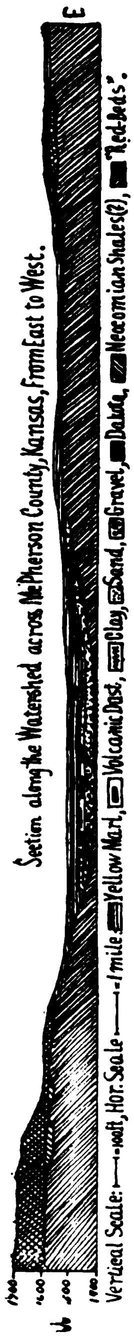


MAP OF KANSAS

The heavy line represents the course of the water-shed between the Kansas and the Arkansas systems: the shaded part represents the ancient trough crossing it. (Am. Geologist, vol. 5, p. 67.)

The eastern border of the Dakota sandstone runs in the general direction from the southwest to the northeast through the central part of the state. With its wide fringe of scattered outliers it makes the most rugged topography in the state. Such topography is well adapted to preserve remnants of later materials imposed upon it. In the belt of Dakotan outliers referred to, there is a trough-like depression several miles wide and perhaps fifty miles

O. St. John, Fifth Biennial Report of the State Board of Agriculture, pp. 146-151.—*F. W. Cragin*, Bulletin of the Washburn College Laboratory, March and April, 1885.—*R. T. Hill*, Texas Geol. and Sci. Bulletin: Austin, Oct., 1888; The American Geologist, Jan., 1890.—*Robert Hay*, Sixth Biennial Report, Kansas State Board of Agriculture, p. 104.—*E. D. Cope*, Tertiary Vertebrata, p. 4—*Dr. Samuel Aughey*, Physical Geography and Geology of Nebraska, 1880.—*Prof. J. E Todd*, Science, April 23, 1886. Proceedings of the American Association for the Advancement of Science, Vol. XXXVII.



The topography of this section is from a map kindly furnished by the Director of the U. S. Geological Survey (Kansas, Hutchinson-Sheet; Contour Interval, 20 feet). The geology is from personal observations and from the reports of well-diggers. The horizontal line seen in the central depression represents the supposed water-level at the time of the falling of the volcanic dust. The eastern end of the section does not follow the water-shed in its sudden turn to the north.

long extending north and south from the city of Salina to about fifteen miles south of McPherson. The superficial material in the bottom of this depression is composed of the deposits in question, while the borders expose the underlying country rock, the so-called "Red-Beds" and the Dakota sandstone. It suggests an old valley partly filled with sediments and now again under excavation. The Smoky Hill river has carved its bed through the northern end, and here erosion has nearly reached the old bottom, and the river has thrown its mantle of alluvium over extensive areas along its course. The southern end, extending from the valley of the Smoky to that of the Little Arkansas, is marked by a rather steep slope along the western margin and by a chain of lakes and basins, that make a rather unique feature in a country otherwise well drained. This end is crossed at right angles by the water-shed between the two principal drainage systems of the state, the Kansas and the Arkansas. As might be expected, the deposits here attain their greatest thickness, which cannot be far from 150 feet. It is at a point where a line of minimum erosion, the watershed, intersects a line of maximum development, the trough.

Taken in ascending order, the materials deposited in the southern end of the trough are as follows: (1) gravel, (2) sand, (3) clay, (4) volcanic dust, (5) yellow marl. The thickness of each of these, as well as their composition, even that of the clay, is very variable. The gravel is mostly confined to the deeper parts of the trough. It is mostly strongly cross-bedded and it varies considerably in coarseness. In a few places carbonate of lime is present as an efficient cement. Pebbles of different kinds of crystalline rocks are not un-

common, and occasionally some are found of purest crystalline quartz. The gravel also contains fragments of silcified wood and of petrified mammalian bones. Occasionally round masses of clay are met with. Near the city of McPherson, where extensive excavations have been made in the sand, a number of angular boulders of Cretaceous clay have been laid bare, some of which are over eight feet in the direction of their longest diameter. These boulders must have been transported a considerable distance, for no similar rocks are known to occur undisturbed within a distance of thirty miles. At the same place just above the sand and gravel in a somewhat soil-like stratum there was exposed in the bank, a few feet apart and extending for a distance of at least two rods, two layers of rounded boulders of a pure white calcareous substance and having a diameter of from three to eighteen inches. They were crowded together and their position was such as to suggest that they were left in their present position by stranded ice. This suggestion is supported by the circumstance that the locality is towards the rim of the trough. As far as the writer has been able to find out, the material of these boulders is unlike any rock found in the state. It consists of an aggregate of crystals of carbonate of lime (arragonite?) with an average length of .0001 mm. Mr. Geo. P. Merrill, who has examined it, says he has seen similar material from the Cretaceous of the south. That these boulders have been transported by floating ice does not admit of a doubt, and a southern or south-eastern extension of the water in which the ice floated, would not seem improbable. A large chert-pebble from the gravel was found by Mr. E. O. Ulrich to contain several bryozoans from the the Sub-carboniferous.* From the gravel and sand have been taken the following fossils, identified by professors E. D. Cope and R. Ellsworth Call (Nos. 1 and 2 are from the bottom of the gravel, the others from near the top of the sand):

1) Megalonyx, sp.† 2) Equus major De Kay.

*Professor J. W. Spencer thinks central Missouri affords evidence of a northern (north-western ?) extension of the waters in which some of a subaqueous drift described by him was deposited. See "Sand-boulders in the drift, etc.," by J. W. Spencer, Am. Nat., October, 1887, p. 921. The bryozoans in the pebble examined by Mr. Ulrich were Fenestella aperta Hall, F. compressa Ulrich, and Polypora maccoyana Ulrich, the two last ones belonging to the Keokuk group.

†The fossil is a skull, which quite closely resembles Megalonyx jeffersoni Harlan, but differs from this in some important respects. At an early date it will be described by Dr. J. Lindahl as Megalonyx leidyi in

3) Spherium striatum Lam.
4) Spherium sulcatum Lam.
5) Pisidium abditum Haldeman.
6) Anodonta, sp.
7) Valvata tricarinata Say.
8) Gammarus, sp.

The top of the gravel changes into sand and this by transitions becomes clay. At first this clay is mixed with coarser material, but this disappears above, where it is entirely homogeneous. At one place it is very fine and has a jointed structure. The joints show beautiful dendritic impressions of manganese oxide. At another place it is coarser, the jointed structure is absent, and the manganese (?) is seen only as distant blotches. As far as known the thickness of the clay does not exceed four feet.

Resting on the clay and separated from it by a well defined line of contact, there is a stratum of volcanic dust which has been

The dotted part represents the area over which the Pleistocene is at least 75 feet deep. The representation of the Cretaceous is from memory.

identified at six places that run in a line across the trough on the north slope of the watershed. The altitudes of these exposures range from 1430 to 1480 feet above the sea level. In the outcrop occupying the lowest level, the material is well assorted, the fine and the coarse grains being separated into intermingled, but distinct, thin layers. It has here settled through a considerable depth of water. At another place where it occupies a position about 40 feet higher, the particles are not assorted, the bed rests on a thin black seam containing bog-manganese and bog-iron, and underneath the jointed clay is dark and carbonaceous. This sug-

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the Proceedings of the Phil. Ac. of Nat. Sciences. The specimen was figured in the August number of the American Naturalist for 1890.

gests the bottom of a swamp. In the lower part of the dust there are vertical holes and impressions of round and triangular stems and V-shaped leaves or sedges that evidently were slowly buried under the falling dust. Mere shreds of these plants remain in the empty moulds, but in some of these there are siliceous skeletons of fresh-water algae, which must have become entangled on the stems of the sedges. The water cannot have been deep at this place, when the dust fell. Above the hight to which the impressions of the buried vegetation extend, the deposit becomes ripple-bedded. Evidence of the rocking motion of the not very distant surface-waves of the water is also seen in the formation of pills, somewhat resembling pisoliths, which are found imbedded in the dust and must have been rolled together by the waves. There can be but little doubt that the surface of the water was within a few feet of the top of this deposit, when it was formed. If such was the case and if the locality does not represent an old isolated pond, as does not appear likely, then it furnishes a clue to the relative hight of the water level at the time of the falling of the dust. In such case it is certain that the water presented an expanse several miles wide in the trough described, and this must have been confluent with another and still wider body of water in the Smoky Hill river valley to the north. The Cretaceous buttes to the east and to the north were not submerged, and to the north-west the same rocks must have formed a considerable stretch of land, even if allowance is made for a subsequent tilting of eight feet per mile to the east.

The top of the volcanic dust gradually changes to a buff-colored loam, which in many places resemble loess. It is rich in carbonate of lime, which often forms concretions. It varies in coarseness from that of fine sand to coarse clay, and sometimes acquires a drab color. The thickness of this deposit is greatest in the middle of the trough, but it extends over the borders of this, and though often modified by the action of wind and water, I think it may be regarded as a remnant of the latest general deposits of the plains in this region.*

*I suspect that this is the same as the "loess-like" formation in Nebraska described by F. W. Russell in the AMERICAN GEOLOGIST for Jan., 1891, and that it is related to the lake sediments spoken of by Dr. L. E. Hicks in his paper on "An Old Lake Bottom," (See Bull. Geol. Soc. Am. Vol. 2, p. 25, etc.) The peculiar topography described in this paper is duplicated on a smaller scale in the lakes and basins of McPherson county.

In conclusion, then, I wish to call attention to the following points: (1) Previous to the last deposition of sediments the country had much deeper drainage-channels than at present. (2) The time of the making of the gravel and the sand being coincident with a period of increasing humidity, changes of the water-level may have caused minor local unconformities between deposits that are closely consecutive in time. (3) The volcanic dust was not deposited in waters forming one great lake in this region. (4) The fauna of the Equus beds and that of the Megalonyx beds must have been, at least to some extent, contemporaneous*.

Augustana College, Rock Island, Ill.

ON THE PHYSICAL GEOLOGY OF TENNESSEE AND ADJOINING DISTRICTS IN THE UNITED STATES OF AMERICA.

By Dr. Edward Hull.†

WITH NOTES AND COMMENTS.

By *Aug. F. Foerste*, Cambridge, Mass.

The Unaka Range, on the boundary of Tennessee, is composed chiefly of granite, gneiss, and crystalline schists, presumably of Archæan age, and forming a prolongation of Prof. Dana's "Ar-

* This statement is based on the authority of professor Cope, who has determined the age of the deposits from the fossils named above, and who published a figure of the Megalonyx skull in American Naturalist Vol. XXIII, Pl. XXXI. The statement made by him in the same place, that the skull was "found in the Ticholeptus beds of Kansas" was a *lapsus calami* afterwards corrected by himself. In a letter to me written a year before the publication of this number of the Naturalist, he gives the age of the fossils as Plistocene. The occurrence of E. major and Megalonyx in the same gravel seems to verify professor Cope's supposition that the Equus beds run into the Plistocene, when he says (Tertiary Vertebrata, p. 4.): "A probably continuous succession of lakes has existed from this period (Loup Fork) to the present time in ever-diminishing numbers;" and it also bears out his guess that, "this fauna (Equus) was probably contemporaneous with that which roamed through the forest of the eastern portion of the continent, whose remains are enclosed in the deposits of the caves excavated from the ancient limestones." The recent discovery of Megalonyx in undoubted Plistocene deposits in Ohio, the character of the molluscan remains taken from the clay above described, and the evidence of ice-action in the sand, supports Gilbert's argument that the Equus fauna must be referred to the Plistocene time division (Lake Bonneville, p. 397); and the "old" character of the topography of these beds in Kansas may perhaps help to explain the difference discussed by this same author (p. 401), between the physical and the biotic evidence relative to the age of the Equus beds.

†London Quarterly Journal, February, 1891.

chæan Protaxis." "From the base of the Cambrian beds, where they rest discordantly upon those of the Archæan Protaxis, the whole series of Lower- and Upper-Palæozoic formations succeed each other in *apparently* conformable sequence, except at the junction of the Lower- and Upper-Silurian series, where a probable discordance occurs. Throughout the prolonged period during which these formations were being deposited, there was continuous subsidence with occasional pauses, over the region lying to the west of the Archæan continental area, and successive formations of marine strata were laid down in vast sheets over the bed of the ocean, never very deep. In later Carboniferous times the marine deposits gave place to those of lacustrine or estuarine origin, but still without any apparent discordance in the stratification; so that the Upper and Lower Carboniferous beds are apparently conformable to each other, and these again to the Devonian and Upper Silurian." This sequence of conformability might just as well have been extended down into Lower Silurian horizons since *no actual discordance* was observed in Tennessee, and conditions noticed in New York and the New England states do not determine the presence or absence of breaks in the conformability of strata in a neighboring state. Tennessee however is far distant.

"The prolonged period of subsidence and deposition above described at length gave place to an epoch of elevation and contraction of the crust, acting with greatest effect and intensity along the line of the Alleghanies,. . . . . where the Palæozoic strata are folded, flexured, and even reversed along parallel axes. . . . . The foldings of the strata, it is well known, generally subside in a westerly direction towards the valley of the Ohio, and ultimately pass into widely extended domeshaped centres of elevation with intervening areas of depression. Amongst the former are the "Cincinnati uplift" and the anticline of the Nashville Silurians; amongst the latter is the region of the Cumberland plateau, which lies along the centre of a broad syncline." It is evident from these remarks that Dr. Hull ascribes the formation of the Cincinnati-Nashville anticlinal to post-Carboniferous times. At the close of this period of folding eastern Tennessee could be termed a great valley, the lowest parts of which lay within the region of the present Cumberland plateau, and the boundaries of which

were the Archæan Protaxis on the east and the crest of the Cincinnati-Nashville anticlinal axis on the west.

This great valley was more or less subdivided by minor parallel flexures. Thus the Sequatchee anticlinal, at present occupied by the valley of the Sequatchee river for a distance of sixty miles extends along the middle of this great valley. "The flanks of the Sequatchee valley are composed of Carboniferous grits and shales resting on limestone, from below which the Devonian and Silurian strata emerge with a dip in the direction of the sides of the valley. The valley is therefore clearly in the line of an anticlinal axis, and to this it probably owes its origin, though it is possible that there may be a fault here running in a parallel direction, along which river-erosion has acted through a lengthened period. The Little Sequatchee, a smaller valley further to the west is probably due to a similar anticlinal flexure." The Tennessee itself, north of Chattanooga, is figured as occupying a secondary anticlinal valley, just east of the present Cumberland plateau. The great valley of east Tennessee, stretching eastward as far as the Archæan Protaxis, is occupied by formations often highly inclined or thrown into flexures.

The region along the Archæan Protaxis, which was perhaps never altogether submerged, was upraised gradually into high land, and thus subjected to extensive erosion long before the more western districts which remained under water and undenuded, or were but slightly emergent. "As time went on, these western tracts wherever in the line of anticlines, were themselves elevated and eroded, and ultimately the synclines themselves." It is evident from the context that the author ascribes most of this erosion to subaerial influences brought to bear upon the land areas while gradually arising from the sea. According to this, the synclines being the last parts to emerge from the sea were the last to suffer erosion. But even then the syncline of the Cumberland plateau region was protected by the massive Carboniferous grits which still capped them, whereas erosion removed this protection from the earlier exposed sides of the great valley, the regions of the Nashville anticlinal and the valley of east Tennessee. The cutting back of the strata no longer protected by these grits, in the direction of their dip, left the synclinal area relatively higher than the anticlines and thus formed the Cumberland pla-

teau, and caused its marked elevation above the surrounding districts.

Special attention is directed to the following sentences (in which the italics do not belong to the original), since they give the author's views as to the emergence of this area from the sea. "In the region with which we are specially concerned, the line of the *Unaka Range and Blue Mountains*, which was *perhaps never altogether submerged*, was upraised gradually into *high land.* The Cambrian and Silurian strata were subjected to erosion; and *streams* carrying the materials *flowed down the flanks of the emergent land into the sea or estuary to the westward.* As time went on, these *western* tracts, wherever in the line of *anticlines*, *were* themselves *elevated* and eroded, and *ultimately* the synclines themselves." The author evidently conceives the existence of the sea in the synclinal region along the Cumberland plateau, *after* the anticlinal area to the westward had already been elevated above the sea. This, however, is not consistent with the main tenor of his paper, of which the following paragraph is a brief digest.

That the Cumberland plateau formerly occupied a relatively lower position than the areas towards the eastward, now occupied by the east Tennessee valley is shown by the Tennessee river at Chattanooga, which instead of continuing its course in a southerly direction into the gulf of Mexico, by crossing a saddle which is only 270–280 feet above its bed, has preferred a channel through the Cumberland plateau rising 1400–1500 feet above its bed. It is evident also that during the time the Tennessee was cutting its channel through the plateau, this area must have been at a lower level than districts farther south, in the region of the saddle to which reference has just been made. Ultimately the Tennessee, instead of continuing its course in a southerly direction into the gulf of Mexico, makes a great sweep to the northward, on the west side of the Cumberland plateau, and joins the Ohio at a distance of about forty miles above the junction of that river with the Mississippi, thus adding to its course a length of about 800 miles!

NOTES AND COMMENTS BY AUG. F. FOERSTE, *Cambridge, Mass.*

The course of the Tennessee at Chattanooga shows that while the river was cutting its channel through the Cumberland plateau, this plateau must have lain at a *lower* level than the land both to

the eastward and towards the south. But the region of the plateau itself must have for similar reasons occupied a *higher* elevation than districts farther down the course of the Tennessee and since this region is at present an anticlinal area it follows that the anticlinal was not in existence at the time when the Tennessee was cutting its channel through the Cumberland plateau, or else that subaërial erosion had, previous to the erosion of this channel, reduced the anticlinal to such a low base-level that this region practically offered no impediment to the courses of streams across it. The latter view, however, scarcely seems tenable, nor does it seem to be the view held by Dr. Hull.

The view that the Tennessee river was in existence before the Nashville anticlinal and maintained its channel across the Nashville anticlinal area during the process of the development of the fold which characterizes it, is made more probable by similar phenomena farther northward. Thus the Cumberland in northern Tennessee, and the Green and Kentucky rivers in Kentucky cross the anticlinal on their way to the Ohio. The Licking river joins the Ohio at the very crest of the anticlinal. The Ohio itself, from the mouth of the Sandy river to its confluence with the Mississippi is itself a striking example of a river crossing the Cincinnati-Nashville anticlinal.

If this view be correct then the elevation of the land above sea level preceded the folding. This elevation must have been most strongly marked towards the east and its inclination must have been sufficient to have given a marked westward flow to the rivers flowing down its flanks into more western seas. At one time this emergent land area must have extended as far and even perhaps beyond the region later occupied by the Cincinnati-Nashville anticline. In this land area the rivers probably secured more or less fixed water channels. Then folding took place. The Tennessee, Cumberland, Green, Kentucky, Licking and Ohio, the *anteplicate* rivers, managed more or less successfully to maintain their old courses in spite of the folding along the anticlinal. If the Great Kanawha with its former course through Teaze's valley to the Ohio near Huntington, West Virginia, be considered the upper course of the Ohio, then the Great Kanawha and the upper courses of the Tennessee offer excellent examples of rivers which also maintained their *courses across the sharper folds* of the Alleghany mountains along their *upper* courses. The Big Sandy is very

likely another of these early rivers. Of course only the stronger streams could maintain their courses across the obstruction caused by the rising folds. As a rule an entirely new river system was developed in the more strongly folded areas of the Alleghanies. Even the Ohio river itself from the mouth of Teaze's valley to a point near the southwestern corner of Pennsylvania, and the lower course of the Alleghany seem to be of later age than the period of folding and occupy approximately the middle of the great synclinal valley between the Cincinnati anticlinal and the Alleghanies.

The northwestern tributaries of this newer portion of the Ohio often have a strikingly similar direction to those which enter the Ohio from the other side. When such streams from opposite sides enter the Ohio at about the same point, they are suggestive of the existence of a former continuous stream which had been cut in two by the process of folding and the formation of the synclinal portion of the Ohio. The northwest stream in this case may then be considered to have had its flow *inverted* as far as the Ohio. However the mere fact that the streams are flowing towards the centre of a synclinal trough might also be considered a sufficient explanation for their existence.

If land conditions over the area here discussed, previous to the period of folding be admitted, then the intersection of the Cincinnati-Nashville anticlinal by the rivers mentioned is not so surprising. Then also the cutting of the channel of the Tennessee across the Cumberland plateau near Chattanooga is made possible. That such land conditions existed is made probable by the disappearance of all marine fossils soon after the opening of the Coal Measure period, and the finding of stumps of trees in many of the deposits of this period *in situ*, at widely scattered points of this area.

The Tennessee river at present has a channel 1400–1500 feet below the more elevated portions of the Cumberland plateau where it cuts through this tableland. At the time it was maintaining its course across the growing obstruction of the Cincinnati-Nashville anticlinal, it very likely had a relatively much higher altitude; indeed its course at that time may have been a thousand feet, or even more above its present bed. If during this period, while the channel of the Tennessee was a much less striking feature in this synclinal region, the level of the sea was not much below the general level of the present Cumberland plateau,

for a long period then conditions would be present for the formation of a base-level of erosion. The synclinal areas lying at small altitudes above the level of the ocean would be less eroded and the more elevated portions would be most strongly subjected to destruction by subaërial influences. The great depth of the present channel of the Tennessee however may have been attained first during the subsequent history of this land area.

Dr. Hull's paper is a valuable contribution to the geographical geology of Tennessee. Whether he would agree with many of the statements made in the notes accompanying the present notice is another question. It is hoped however that for American readers these notes will not be found out of place, but will serve to suggest some of the lines of research opened by Dr. Hull's paper, to those American geologists whose geographical location will permit the prolonged study of the areas here involved.

THE GEOLOGICAL POSITION OF THE CATSKILL GROUP.

By Charles S. Prosser. Washington.

A recent publication by the Geological Society of America* contains an abstract of a paper by Dr. Henry S. Williams, entitled "What is the Carboniferous System?" Professor Williams refers to the difficulty that American geologists have experienced in attempting to separate the Upper Devonian from the Lower Carboniferous and states that this confusion is due to "a lack of precise definition as to the constitution and limitation of the Carboniferous system."† The works of the early English geologists have been carefully studied and it is shown that the system was first defined by Conybeare in 1822 as "the rocks which form the Pennine....range of mountains in northern England."‡ The section of this Pennine Carboniferous system consists of: 1st, the upper part of the Old Red sandstone resting upon lower beds of Old Red sandstone; 2d, the "Mountain or Carboniferous limestone;" 3d, the "Millstone grit and shales"; 4th, the "Coal Measures" which are terminated, generally unconformably, by the New Red sandstone. The author states that since "The typical section is the section exhibited in the Pennine range; and as the name Carboniferous is a misnomer geologically....and as the

*Bulletin Geol. Soc. Am. Vol. 2, Jan. 3, 1891, pp. 16–20.
†*Ibid.*, p. 16. ‡*Ibid.*, p. 17.

name does not indicate the geographic position of the typical section it is believed that the adoption of the name 'Penninian system,' or 'Pennian system' (the latter being preferable), may be of advantage to the science ".* Finally, the Appalachian Paleozoic rocks are correlated with the Pennian as follows: "The Chemung marine fauna is strictly Devonian; the brackish water fish fauna of the Catskill is as strictly Pennine. Hence the red rocks of the Catskill formation of New York, the Ponent, Umbral, and Vespertine formations of Pennsylvania, belong to the Pennine carboniferous." Proceeding westward the Pennine will include "the formations called Waverly, Marshall, Kinderhook, Chouteau, containing, as they do, a fauna distinctly related to the Carboniferous limestone fauna."†

In connection with the paper just reviewed, an earlier opinion of Dr. Newberry is of especial interest. After calling attention to "the correspondence of the fauna of the Catskill and Upper Old Red sandstone of the British Islands" he said: "It has troubled the English geologists much to draw any well-marked line, in the series to which I have referred [Old Red Sandstone of England, Scotland and Ireland], between the Devonian and the Carboniferous systems; but there are none who do not regard as Carboniferous at least a portion of the yellow sandstones which underlie the Carboniferous limestone, and contain *Holoptychius* as a characteristic fossil. Hence it will be seen that in the Catskill of Pennsylvania we have strata which are not only lithologically similar to those which in Scotland and England lie at the top of the Devonian and base of the Carboniferous system, but that this similarity of mineralogical character and geological position is accompanied by a similarity of fauna."‡

About the only fauna contained in the Catskill group is "the brackish water fish fauna"§ of which *Holoptychius* and *Bothriolepis* are characteristic genera. The following ten species of fossil fishes have been reported from the Catskill of New York and Pennsylvania and are described by Dr. Newberry in his excellent work on "The Paleozoic fishes of North America."‖

**Ibid.*, p. 19. †*Ibid.*, p. 19.

‡Rep't. Geol. Surv. Ohio, Vol. I, Geol. and Pal., Pt. II, Pal., 1873, pp. 275, 276.

§Dr. Newberry thinks that "the Catskill rocks were deposited in a fresh-water lake." Mon. U. S. Geol. Surv., Vol. XVI, p. 106. Also, see table of groups of the Carboniferous system on p. 77, and p. 101.

‖Mon. U. S. Geol. Surv., Vol. XVI.

Bothriolepis leidyi Newb.	*Holoptychius* (?) *radiatus* Newb.
Sauripteris taylori Hall.	*Glyptopomus sayrei* Newb.
Holoptychius americanus Leidy.	*Dipterus*(*Ctenodus*)*sherwoodi* Newb
" *giganteus* (?) Ag.	" " *radiatus* Newb.
" *halli* Newb.	*Gyracanthus sherwoodi* Newb.

The crustaceans are represented by *Stylonurus excelsior* Hall from Andes, New York and Meshoppen, Penn'a. A species of lamellibranch, *Amnigenia catskillensis* (Van.) Hall, which is rather characteristic of the Oneonta sandstone, has been reported from the Catskill of Bedford Co., Penn'a.,* and it is not at all improbable that it will yet be found at other localities in the typical Catskill.

So far as paleontology is concerned, the principal change involved in this correlation is in reference to the paleobotany. By including the Catskill in the Lower Carboniferous a considerable proportion of the American Devonian flora would be transferred to the Carboniferous or Pennian system. It will be remembered that Sir Wm. Dawson, to whom we are indebted for most of the description of this flora, has always insisted that it is a Devonian flora quite distinct from that of the Lower Carboniferous. This opinion was clearly stated by Dawson in 1882 when he defined the "Upper Erian Sub-flora" as corresponding "to the Catskill and Chemung of the New York series, and to the Upper Devonian of Europe," and stated, in conclusion, that it is "very distinct from that of the Lower Carboniferous."†

A rather careful review of the fossil plants, now known to occur in the typical Catskill of the United States, fails to show any marked reason for considering them as necessarily Devonian. In fact some of the other paleobotanists have been inclined to consider the flora of the Upper Devonian as of Lower Carboniferous facies. The most abundant ferns in the Catskill belong to the genus *Archæopteris*, which appeared in the Chemung and probably extends through the Lower Carboniferous into the Coal Measures. This genus is represented in the Culm of Austrian Silesia, Hesse, Moravia, and Silesia by several species, also in the

*2d Geol. Surv. of Penn'a. T^2. The Geology of Bedford and Fulton counties, p. 103. It is mentioned under the name of *Modiola angusta* Con., which is considered a synonym of *A. catskillensis* (Van.) Hall. See Geol. Surv. N. Y., Pal. Vol. V., Pt. I, Lamellibranchiata II, pp. 516, 517.

†Geol. Surv. of Canada. The fossil plants of the Erian (Devonian) and Upper Silurian formations of Canada, Pt. II, p. 130.

Upper Devonian and Lower Carboniferous of Australia and Carboniferous (Coal Measures?) of China; so that the evidence afforded by the most prominent genus of ferns would be as strongly in favor of classing the Catskill with the Lower Carboniferous as with the Chemung or Upper Devonian.

A short analysis of the American Catskill flora may be of some interest in connection with this subject. The Catskill of New York and Pennsylvania contains, so far as reported, thirteen species, of which number seven belong to the genus *Archæopteris*. A few species that were described as from the Catskill have been omitted from the list, owing to the fact that a more accurate knowledge of the geology of the region has shown them to belong to the Oneonta sandstone, or Chemung; but, it is thought that all the species mentioned in the following list occur in the Catskill as now restricted and defined. The species are as follows:

1. *Arcæhopteris jacksoni* Dn.*

*In 1869 Schimper referred with doubt *Cyclopteris jacksoni* Dn. to *Palæopteris halliana* (Göpp.) Sch., now *Archæopteris* (Traité pal. vég., Vol. I, p. 478.) Dawson in 1871 objected to this identification, stated that it was a distinct species and put it in what was then considered the sub-genus *Archæopteris* of *Cyclopteris* (Fos. Plants Dev. and Up. Sil., Pt. I, p. 48.) Schimper in 1874 accepted Dawson's defence of the validity of the species and gave it as *Palæopteris jacksoni* (Dn.) Sch. (Traité pal. vég., Vol. III, p. 484.) In 1882 Dawson elevated the sub-genus *Archæopteris* to generic rank and gave some additional information about *A. jacksoni* Dn. (Fos. Plants Erian and Up. Sil., Pt. II, p. 100.) In 1888 it is mentioned as *A. jacksoni* and figured on p. 74 of Dawson's "Geological history of plants;" while its author in 1889 again stated that it is a distinct species from *A. halliana* (2d Geol. Surv. Penn'a, P[4], Vol. I, errata p. VI.)

The *Cyclopteris jacksoni* Dn. is stated by Dawson in 1862 (Quart. Jour. Geol. Soc. London, Vol. XVIII, p. 319) to have been found at Montrose, New York, which is undoubtedly Pennsylvania. Professor Hall in 1863 (16th An. Rep't. of the Regents of the State of N. Y. on the State Cabinet of Natural History. Appendix D., p. 110) identifies the specimen found near Montrose, Penn'a. and described by Vanuxem (Geol. N. Y., Pt. III, p. 192 and fig. 58 on p. 191) as *Cyclopteris jacksoni* (?) Dn. Dawson in 1871 (Fos. Plants Dev. and Up. Sil., Pt. I, p. 46) wrote that "A specimen, obscure in details, but which must belong to this [*A. rogersi* Dn.] or the previous species [*A. halliana* (Göpp.) Lx.], occurs in professor Hall's collection, from Montrose, Pa." On p. 45 *Cyclopteris jacksoni* Dn, is simply credited to the Upper Devonian of N. Y., without giving the locality; but, on p. 91, fig. 169 of pl. xv it is said to be a pinna of *Cyclopteris* (*Archæopteris*) *jacksoni* from Montrose, Penn'a. In the Acadian Geology, 3d ed., 1878, it is stated on p. 547 that "large specimens [of *C. jacksoni* Dn.] occur in the collection of professor Hall from the Old Red sandstone of Montrose, New York." It appears from this that it was not a single specimen that was identified as *C. jacksoni*, or *C. rogersi*; but, that both species were seen from collections made at Montrose, Penn'a.

In explanation of this ambiguity Dr. Dawson wrote me as follows,

2. *Archæopteris hibernica* (Forbes) Lx.
3. " *macilenta* Lx.
4. " *minor* Lx.
5. " *obtusa* Lx.
6. " *rogersi* (Dn.) Lx.
7. " *sphenophyllifolia* Lx.
8. *Cyclopteris valida* Dn.*
9. *Dendrophycus desorii* Lx.†
10. *Dictyo-cordaites lacoi* Dn.
11. *Lycopodites richardsoni* Dn.

February 12th, 1891; "As to the *Montrose* specimens I suppose all of them were from one place, but I may have in the first instance taken it for granted that Montrose is in New York, as the specimens sent to me were in general from that state. As to the *specimens* from Montrose, if my memory serves me, there were several, some of which I referred to *A. jacksoni* but one showing several fronds seemed to me different, and I referred it with doubt to *A. rogersi*. The specimens were returned to Prof. Hall and perhaps should be re-examined, more especially as the more recently found specimens from Scaumenac have given new information."

Prof. I. C. White in 1881 reported this species from opposite Honesdale, Wayne Co., Penn'a. (2d Geol. Surv. Penn'a. G^5, pp. 63, 187), and in 1882 from a cut on the D. L. and W. R. R. below Henryville, Monroe Co., Penn'a. (*Ibid.*, G^6, pp, 103, 320). Finally, Lesley says: "[*C. jacksoni* Dn.] in the *Chemung-Catskill* strata about Montrose, Susquehanna Co., Pa., as described by Hall" (*Ibid.*, P^4, Vol. I, p. 174).

In the Museum of Columbia College, New York, are specimens labeled "*Archæopteris jacksoni*, from Montrose, Pa." Prof. H. L. Fairchild, March 12th, 1891, wrote me the following note: "The specimens of *Archæopteris jacksoni* which you saw in Dr. Newberry's Museum were collected by me. These have been found at different localities through Susquehanna county, Pennsylvania. Most of these specimens came from a quarry near Montrose, Penn. They occurred at the lowest point in the quarry and the stratum was only touched; but, before I knew it, that part of the quarry was filled in. That was many years ago; the fossils are there awaiting some one who is willing to spend the money to excavate for them." According to Prof. R. P. Whitfield, the American Museum of Natural History, Central Park, New York, contains some rather fragmentary specimens labeled "*Cyclopteris jacksoni* from Montrose, Pa." The New York State Museum of Natural History, Albany, N. Y., also contains specimens labeled "*Cyclopteris jacksoni* from Montrose, Pa."

*On p. 830 of the Coal Flora, Vol. III, this species is reported by Lesquereux from simply the "Upper Devonian, Pennsylvania"; but, on p. 885 it is given in the column of Catskill plants, although not mentioned on p. 850 in the list of species from the different localities which have furnishéd Catskill plants.

†The organic nature of *Dendrophycus* is in dispute, Lesquereux described the genus, of which *D. desorii* is the type, as belonging to the marine algæ. Among the paleobotanists Dr. Newberry and Prof. Ward still refer it to the algæ, and each has added another species to the genus, from the Trias; while Sir Wm. Dawson and J. Starkie Gardner do not regard it as of organic nature.

12. *Psilophyton princeps* Dn.*
13. *Rhacophyllum truncatum* Lx.†

There are probably two additional varieties of *Archæopteris*, known from the Catskill of Pennsylvania, which have not been given in the above list. In 1890 Dr. Dawson, upon the authority of Mr. R. D. Lacoe, mentioned *Archæopteris major* Lx., from the Lower Catskill of Meshoppen, Penn'a.‡ But, Mr. Lacoe wrote me February 10th, 1891, as follows: "The information given Dr. Dawson was in answer to general questions as to the fauna and flora of the Catskill of northern Pennsylvania and particularly anything associated with or in beds near to the *Dictyo-cordaites*. I mentioned *Archæopteris minor* Lx., and *A. minor* var. *major* Lx., and very likely not that the variety was unpublished. It is a large form of *A. minor*, separated by professor Lesquereux and a drawing was made of it." February 19th Mr. Lacoe wrote me that "Still another variety [of *Archæopteris*] was described by professor Lesquereux, but not figured." In this last letter Mr. Lacoe stated that "We have *Haliserites dechenianus* Göpp. from the Catskill of Meshoppen, several fine drawings of which were made for professor Lesquereux."

There are references to other fossil plants in the Catskill, most of which are so indefinite that they possess very little value. Mr. Andrew Sherwood identified a *Sphenophyllum* allied to *S. antiquum* Dn. from the Catskill, four miles north-west of Mansfield, Tioga Co., Penn'a.§ Prof. I. C. White mentions "small egg-like

*This species was reported by Dr. Dawson from Jefferson, Schoharie Co., N. Y., and at first stated to be Catskill but later, upon the authority of professor Hall, was changed to the Chemung (Quart. Jour. Geol. Soc., London, Vol. XVIII, p. 315 and additional note opposite p. 329). In reference to the geological age of this locality Dr. J. M. Clarke wrote me, March 5th, 1891, that "The horizon at Jefferson, Schoharie Co., where the *Psilophyton princeps* came, is Hamilton. From there upward the succession is still a question for determination."

However, the presence of this species in New York rocks, considered as of Catskill age, is shown near the close of this paper.

†Mr. R. D. Lacoe writes me that all of the species in the above list, with the exception of *Archæopteris jacksoni* Dn., *Cyclopteris valida* Dn. and *Psilophyton princeps* Dn. are recorded from the Catskill without doubt. It is well known that Mr. Lacoe's collection of American Paleozoic plants, at Pittston, Penn'a., is the most complete in the world; and, I wish to acknowledge the great assistance of this collection in verifying the range and distribution of the species mentioned above. I would also state that I am greatly indebted to Mr. Lacoe for his kindness in sending me this data; as well as for other assistance in the study of Devonian fossil plants.

‡Canadian Record of Science, Vol. IV., p, 6.

§2d Geol. Surv. Penn'a. G, p. 80.

bodies which Prof. Claypole suggests are spores of plants" from above Coxton, Lackawanna Co., Penn'a.* Professor Lesquereux identified a *Lepidocystis*, species undeterminable, from Meshoppen, Penn'a.†

One of the seven species of *Archæopteris*, *A minor* Lx., has been identified by George B. Simpson from the Chemung at Roulette, Potter Co., Penn'a.;‡ while *A. obtusa* Lx. is reported by Dr. Dawson from the Upper Devonian of New Brunswick under the name of *Cyclopteris obtusa* (Lx.) Dn.§ *Archæopteris jacksoni* Dn. occurs in the Middle Devonian of St. John, N. B., the Upper Devonian of Scaumenac bay, Lower Quebec, and at Perry, Maine.‖

**Ibid.*, G^7, p. 61; also, see p. 58.

†*Ibid.*, O^3, Cat. Geol. Mus., Pt. III, 1889, p. 116.

‡*Ibid.*, p. 248. Sherwood in his report on "the Geology of Potter County" mentions the occurrence of plant stems in the Chemung gray shale at this locality and says that "The Carboniferous stems of *reed-like plants*, in particular, are quite numerous"(*Ibid.*, G^3, p. 30.) Prof. Lesquereux identified a specimen said to have been found at Towanda, Penn'a. as belonging to the above species (Proc. U. S. Nat. Mus., Vol. X, p. 24). The specimen is marked "Towanda Pa., from a boulder" and it is not stated whether from the Chemung or Catskill. If it came from the sandstone outcrops near Towanda it would belong to rocks that have been considered as Chemung. See the geological map of Bradford Co., by Andrew Sherwood, and in the accompanying report it is stated that "opposite and a little above Towanda, there is an extensive out-crop [of Towanda sandstone]....containing carbonized stems of reed-like plants" (2d Geol. Surv. Penn'a. G, p. 38). While in 1885 Prof. Lesley wrote that "opposite Towanda is an outcrop of Chemung sandstone 300 feet thick crowded with carbonized plant stems" (*Ibid.*, X, p. XXVIII).

§Geol. Surv. Canada. Fos. Plants Erian and Up. Sil. Pt.II, p. 100.

‖In 1874 Prof. Fontaine reported this species from the "Great Conglomerate" of New river, near Sewell Station, West Virginia (Am. Jour. Sci., 3d ser., Vol. VII, p. 57); and also from what he then considered Catskill shales, but later changed to Vespertine, at Lewis Tunnel (*Ibid.*, p. 578). Two years later he mentioned its rare occurrence in the "Conglomerate Series" of West Virginia under the generic name of *Palæopteris*, but stated that "Only one or two small fragments of this plant were found at Sewell Station with coal 9" (*Ibid.*. Vol. XI, 1876, p. 383). It is there stated that the specimens from Lewis Tunnel are not identical with *A. jacksoni* as will be seen from the following paragraph of the article: "I may state here that the *Palæopteris jacksoni* of the Conglomerate series, is the typical plant, and very different from the plant found at Lewis Tunnel, and given in my previous paper as *P. jacksoni*. I have additional specimens from Lewis Tunnel, which show without doubt that. as professor Andrews has suggested, this latter is a new species" (*Ibid.*, p. 384). In 1880 it was stated by Fontaine and White, in enumerating the flora of the Conglomerate group of New river, that "we find a small *Archæopteris*, very near to Dawson's *Cyclopteris jacksoni*" (2d Geol. Surv. Penn'a. P^2, p. 12). In explanation of the above references professor Fontaine wrote me, March 8th, 1891, as follows: "Only one specimen was found at Sewell Station and it did not show much of the plant. My opinion now is that it was not sufficient to determine positively the fossil as *Archæopteris jacksoni*. It must be regarded as of doubtful position."

Four species, *A. hibernica* (Forbes) Lx., *A. minor* Lx., *A. obtusa* Lx., and *A. rogersi* (Dn.) Lx., are known to occur in the Pocono or Subconglomerate of the Lower Carboniferous. *A. sphenophyllifolia* Lx., has been found in the Lower Catskill of Meshoppen, Penn'a., and *A. macilenta* Lx. is from Meshoppen and the Catskill of the D. L. and W. R. R. tunnel, north of Factoryville, Penn'a. Of the remaining six species *Psilophyton princeps* Dn. is known in the Hamilton and Chemung of New York* and is reported as low as the Upper Silurian of Canada; while *Rhacophyllum truncatum* Lx. is stated by its author to occur in the Subconglomerate of Tennessee.† *Dendrophycus desorii* Lx. occurs in the Subconglomerate of Penn'a., and in Iowa in a clay that is stated by professor Barris to belong to the Coal Measures.‡ *Cyclopteris valida* Dn. occurs in the Middle Devonian of St. John, N. B.;§ *Lycopodites richardsoni* Dn., is in the probable Catskill

*Prof. I. C. White found "vegetable fragments which resemble *Psilophyton princeps* Dn." in the Upper Chemung, near Danville Station, Montour Co., Penn'a. (2d Geol. Surv. Penn'a. G^7, p. 307).

†This species was first given by Lesquereux as from the "red shale of the Vespertine on the bluffs of the Susquehanna river above Pittston" (2d Geol. Surv. Penn'a. P, Coal Flora, Vol. I, p. 312). While in Vol. III, p. 850 it was stated to occur in the Catskill of Coxton Narrows, Penn'a; but was not mentioned under the Pocono or Subconglomerate of Penn'a. Mr. Lacoe wrote, February 19th, that "*Rhacophyllum truncatum* has been found at but one place [in Penn'a.] and that is in the Catskill as placed in the Table in P. Vol. III, and G^7, pp. 60, 61, where Prof. White mentions the *A. minor* in No. 20 of the Coxton section. Prof. Lesquereux was misled by the thinning out of the Pocono northward, when the table in Coal Flora, Vol. II was made, and the habitat of *R. truncatum* given, on p. 312, Vol. I, as Vespertine."

‡Proc. Davenport Acad. Nat. Sci., Vol. III, Pt. II, 1882, diagram on p. 164 and pp. 166, 168.

There appears to be no evidence in support of Lesquereux's statement that this species occurs in the Devonian of Iowa. (See, 2d Geol. Surv. Penn'a. P, Vol. III, p. 701; and, *Ibid.*, An. Rep't for 1886. Pt. I, 1887, p. 462).

§Prof. Fontaine stated that "*Cyclopteris valida* is common" at Lewis Tunnel (Am. Jour. Sci., 3d ser., Vol. VII, 1874, p. 578); but, in 1880, it was not positively identified, the reference being that "More rarely we find a *Neuropteris* allied to *N. flexuosa*, but, if not identical with it, a plant allied to Dawson's *Cyclopteris valida* (2d Geol. Surv. Penn'a. P^2, p. 7). In the above reference it is not quite clear whether one or two species are meant: but, Prof. Fontaine's letter shows that two species were under consideration. The professor writes "With reference to *Cyclopteris valida*, I would say that the plant found at Lewis Tunnel, and supposed to be it, did not yield a sufficient amount of material to render its identification positive. This must then be left as a doubtful *C. valida*..... But there is one correction that I would make [in reference to the account of the Vespertine flora in P^2.] At the top of p. 7, it is stated that there is found at Lewis Tunnel a *Neuropteris* allied to *N. flexuosa*. This I have found to be a form of *Archæopteris hibernica*."

of Perry, Maine; and, *Dictyo-cordaites lacoi* Dn. is known only from the Lower Catskill of Meshoppen, Penn'a.

In the range and distribution of the species mentioned above some doubtful references have been omitted and most of the foreign localities have been ignored, because they offer no particular assistance in the solution of this question. The above summary is to be regarded as simply a preliminary one, based on published accounts of this flora, which will be somewhat modified when all the collections of Catskill plants have been studied. Up to the present time the collections of Devonian fossil plants of the United States have been widely scattered; no paleobotanist has had the opportunity of studying all the material, and in fact some of the important specimens have scarcely been examined. It yet remains for a paleobotanist to describe the Devonian flora of the United States as Lesquereux did the Carboniferous or as Dawson has the Paleozoic flora of Canada. Yet, it is believed that the genus *Archæopteris* may be regarded as including the predominant fern life of this period, which appeared, like the *Holoptychius* fauna, in the preceding Chemung stage and has continued for a considerable length of time in the Lower Carboniferous. If we accepted Dr. Newberry's correlation of the Devonian and Lower Carboniferous and drew the dividing line at the base of the Chemung stage,* then the genus *Archæopteris* might be regarded as characteristic of the Lower Carboniferous. But, as professor Williams shows in the above paper, this does not agree with an accurate interpretation of the typical Carboniferous section and the professor has given proof elsewhere† that the Chemung stage should be included in the Upper Devonian.

Professor Lesley has recently published an interesting note upon the Pocono flora, which would apparently strengthen the claim of classing the upper portion of the Devonian with the Lower Carboniferous. The general nature of the evidence may be seen from the following excerpts: "As this goes to press (October 23, 1890) I received an important letter from Mr. Lacoe, of Pittston, Pa., saying that he has cursorily examined the contents of some of the boxes forwarded by his collector of fossil plants at the

*See Mon. U. S. Geol. Surv., Vol. XVI. The Paleozoic Fishes of N. A., pp. 23, 77, 84.

†Bull. U. S. Geol. Surv., No. 41. On the fossil faunas of the Upper Devonian—the Genesee section, New York, Chap. I; Am. Jour. Sci., 3d ser., Vol. XXXV, p. 54.

Tom's creek, Blacksburg and Price's mountain mines in Montgomery county, Va., and believes that important consequences will follow a thorough study of all the specimens. This is the first good collection of plants from these otherwise extraordinary coal beds of the *Pocono formation* No. X. The few which I obtained thirty-five years ago at Tom's creek were enough to show Lesquereux that they were rightly placed *beneath the red shale of* XI.....The flora as a whole is nearer *Devonian* than *Carboniferous* in type....Those Montgomery county boxes which Mr, Lacoe opened *show a complete absence of Carboniferous forms.*"*

There still remain for consideration the famous plant-bearing beds at Perry, Maine, which have yielded a larger number of species of fossil plants than has yet been described from the Catskill of N. Y. and Penn'a. The geological position of this flora has long been in question, but the latest reference brings it within the scope of this paper. Sir William Dawson described the flora and considered it as probably Upper Devonian,† an opinion that is stated by the author in later publications without qualification.‡ On the geological maps of the Canadian survey it was colored as Lower Carboniferous and said by Bailey and Matthew to be "a group of beds lying at or near the base of the Lower Carboniferous series, and characterized by an Upper Devonian flora." § While more recently professor Bailey has referred it to the Devonian and stated that it most nearly resembles the Catskill of New York.[1]

Nineteen species of fossil plants have been described from Perry, Maine; the list being as follows:

1. *Anarthrocarna perryana* Dn.	10. *Lepidostrobus globosus* Dn.
2. *Archæopteris jacksoni* Dn.[2]	11. *Leptophlœum rhombicum* Dn.

*2d Geol. Surv. Penn'a. P^4, Vol. III, 1890, Critical Emendations, p. XIII, Note.

†Can. Nat. and Geol., Vol. VI, 1861, pp. 172–175; Quart. Jour. Geol. Soc. London, Vol. XVIII, 1862, p. 296, etc; *Ibid.*, Vol. XIX, 1863, pp. 458–465.

‡Geol. Surv. Canada. Fos. Plants Erian and Up. Sil, Pt. II, 1882, p. 97; The Geological History of Plants, 1888, p. 107.

§Geol. Surv. Canada. Rep't. of Progress for 1870–'71, p. 200.

[1]Proc. and Trans. Royal Soc. Canada for 1889, Vol. VII, 1890, Sec, IV, p. 60.

[2]*Sphenopteris hitchcockiana* Dn. is here considered as a synonym of *A. jacksoni* Dn. The reasons for this reference are as follows: In 1869 Schimper wrote "Le *Sphenopteris hitchcockiana* de Dawson représente évidemment la fructification de cette espèce [*Cyclopteris jacksoni*]" (Traité pal. vég., Vol. I, p. 478.) Dawson in 1871 considered this statement and said "Schimper suggests that my *Sphenopteris hitchcockiana*

3. *Archæopteris rogersi*(Dn.)Lx.
4. *Carpolithus lunatus* Dn.
5. " *siliqua* Dn.
6. " *spicatus* Dn.
7. *Cordaites flexuosus* Dn.
8. *Cyclopteris* (*Platyphyllum*) *brownii* Dn.
9. *Lepidodendron gaspianum* Dn
12. *Lycopodites comosus* Dn.
13. " *richardsoni* Dn.
14. *Psilophyton elegans* Dn. (?)
15. " *glabrum* Dn. (?)
16. " *princeps* Dn. (?)
17. *Sphenopteris recurva* Dn.
18. *Stigmaria pusilla* Dn.
19. *Trichomanites filicula* Dn.*

Ten of the above species are confined to Perry and the geological range of the remaining nine is given below. The range of *Archæopteris jacksoni* Dn. was given under the list of plants from the Catskill of Penn'a. and New York ; while *A. rogersi* (Dn.) Lx. is in the Catskill of Penn'a. and Pocono of Va. *Lepidodendron gaspianum* Dn. ranges from the Hamilton of N. Y. to the Subconglomerate of Ohio, and *Leptophlœum rhombicum* Dn.† occurs in the Lower Devonian of Campbellton, N. B., and Middle Devonian of Gaspé, Lower Quebec. *Lycopodites richardsoni* Dn. occurs in the Catskill of Penn'a, and *Cyclopteris* (*Platyphyllum*) *brownii* Dn.

may be the fructification of one of the above ferns of the genus *Archæopteris*. I regard this as quite possible, but have no direct evidence of it" (Fos. Plants Dev. and Up. Sil., Pt. I, p. 49.) Under the description of the species it is further stated that "The suggestion of Schimper......that this species may be founded on fertile pinnules of Cyclopteris of the subgenus Archæopteris, is deserving of attention" (*Ibid.*, p. 52); while, on p. 191 in explanation of fig. 175 of pl. XV occurs the statement that "This species may probably be founded on fertile pinnæ of Cyclopteris Jacksoni." Lesquereux in 1880 wrote "That this figure represents the fructification of a species of *Archæopteris* is positive, and Prof. Dawson has already recognized the accuracy of this reference; but, in the absence of sterile leaflets, it is not possible to say to what species the fragment is referable" (2d Geol. Surv. Penn'a. P, Coal Flora, p. 304.) This opinion was re-affirmed by Lesquereux in 1884 when he said that "This plant as figured, appears to represent fruiting branches of some species of *Archæopteris* (*Ibid.*, Vol. III, p. 837.) Finally, Dawson in 1889 provisionally accepts this synonomy and states that he "refers this fructification to *A. jacksoni*, because that is the only species found with it." (*Ibid.*, P[4], Vol. I, Errata, p. VI.)

*In addition to the above list Dr. Dawson has identified specimens as belonging to the following genera; but, owing to the imperfection of the material, he has not been able to identify them specifically.

1. *Aporoxylon* sp. Dn. cf. *primigenium* Ung.
2. *Cyperites* sp. Dn.
3. *Dadoxylon* sp. Dn. cf. *ouangondianum* Dn.
4. *Megaphyton* ? sp. Dn.
5. Unnamed pinnule of fern.

†Wm. Carruthers in 1872 (Quart. Jour. Geol. Soc. London, Vol. XXVIII, p. 351) stated that he regarded this species as a fragment of *Lepidodendron gaspianum*, and on p. 353 identified it as *L. nothum* Ung. *non* Salter. Dawson in 1882 (Fos. Plants Erian and Up. Sil., Pt. II, p. 105) reaffirmed the distinctness of these two species and gave a synopsis of their more distinctive characters.

in the Upper Devonian of Scaumenac bay, Lower Quebec. It is thought by Dr. Dawson that three species of *Psilophyton* have been found at Perry,* *P. glabrum* Dn., which probably occurs in the Upper Silurian at Gaspé, is known in the Lower and Middle Devonian of Gaspé, Lower Quebec, and the Middle Devonian of N. B.; *P. elegans* Dn. Middle Devonian of Gaspé and N. B.; and *P. princeps* Dn., whose range is given above. It will be noticed that this flora is more closely connected with the pre-Carboniferous than with the Caboniferous floras of Canada and New Brunswick, while in the United States it is related about as closely with the Lower Carboniferous as with the Chemung and Hamilton.

A recent letter from Sir William Dawson, in which his views as to the age of the Catskill flora are expressed in a very concise manner, will form an appropriate termination to this review of that flora. The suggestion that the Devonian flora in migrating south and west possibly appeared at a higher horizon, a principle that has been frequently observed in the study of marine faunas, would seem to offer an explanation of the somewhat different opinions as to the age of this flora, that are held by the several paleobotanists who have studied it in different geographical areas. The above sentence calls attention to the fallacy of attempting precise correlation for the geological formations of widely separated regions from simply lists of fossils common to the formations, without careful study and consideration of the stratigraphy and other related geological facts. This rule was probably somewhat overstated by Huxley, in his noted address before the Geological Society of London;† but, a concise and modern exposition of this and other principles for the guidance of "geologists concerning the correlation of formations and the interrelation of presumably contemporaneous fossil faunas and floras" was admirably enunciated by Dr. Charles A. White in 1889.§

Dr. Dawson's letter is given below and since its distinguished author has studied this flora far more carefully than any other

*Quart. Jour. Geol. Soc. London, Vol. XIX, 1863, p. 462.

†Anniversary Address. Quart. Jour. Geol. Soc. London, Vol. XVIII, 1862, pp. XL-1. In particular see p. XLVI where it is stated that "For anything that geology or palæontology are able to show to the contrary, a Devonian fauna and flora in the British Islands may have been contemporaneous with Silurian life in North America, and with a Carboniferous fauna and flora in Africa."

§Address by professor Charles A. White, vice-president, Section E, in Proc. Am. As. Adv. Science, Vol. XXXVIII, pp. 222–226.

paleontologist it is of especial value in this discussion and deserves the most careful consideration.

McGILL COLLEGE, MONTREAL, February 18th, 1891.

DEAR MR. PROSSER:—In reply to your question respecting the age of the Catskill Flora—species of *Archæopteris*, *Cyclopteris valida*, *Rhacophyllum truncatum* (which I think is probably founded on a torn and imperfect specimen of my *Platyphyllum brownii*, as Lesquereux himself suggested), *Lycopodites richardsoni*, *Psilophyton princeps*, etc., etc. I would say that such a flora, if found in Canada, would *certainly* be *Upper Erian*, and not Lower Carboniferous, for the following among other reasons :—1st. This flora occurs at Scaumenac, Bay de Chaleur, in beds holding *Pterichthys* and other Devonian fishes, described by Mr. Whiteaves of our survey,* and underlying uncomformably the lower conglomerates of the Carboniferous (Bonaventure formation of Logan). These beds are mostly grey sandstones and shales with some red beds at top, and the Carboniferous conglomerates are also red, the whole exposed in fine sections.† 2d. We have in Nova Scotia, well exposed and rich in plants, the lowest Carboniferous which I have called the *Horton Series*, and parts of which some of our younger geologists seem disposed, wrongly I think, to class with the Devonian. It contains a quite distinct flora (*Lepidodendron corrugatum*, *Aneimites acadica*, etc.), not found anywhere in the true Upper Devonian beds.

These reasons I regard as conclusive, and they cause me to consider the beds of Perry, in Maine, true Upper Erian, though it is apparently not easy to separate them stratigraphically from beds of similar mineral character in New Brunswick, regarded as Carboniferous.

As the Erian flora migrated from the north and east, it is possible that south and west its plant types may be found at higher horizons, as has been supposed in Ohio (Newberry, Andrews,) and Virginia (Meek, Fontaine,) and therefore I would not be too confident as to these, but would be influenced by associations of other fossils and by distinct species of Devonian genera. As to the Catskill region, however, there is I think every reason to believe that it conforms nearly to our Canadian types of the formation. Truly yours,

J. WM. DAWSON.

It must not be hastily concluded that if the dividing line between the Carboniferous and Devonian be lowered from the top of the Catskill to its base that it will always give a precise dividing line. On the contrary it is doubtful if in the Appalachian Paleozoic area the line separating the Catskill from the Chemung can be determined with as great precision as the line between the Catskill and Pocono. Professor Williams has previously called attention to the difficulty of separating the Chemung from the

*Proc. and Trans. Royal Soc. Canada, Vol. IV, Sec. IV, p. 101.

†See Fos. Plants Erian and Up. Sil., Pt. II, pp. 98–102.

Catskill in eastern New York,* and in his "Report of the Sub-Committee on the Upper Paleozoic (Devonic)" to the Fourth International Congress of Geologists, the professor said, "The Catskill stage in eastern New York follows the Chemung fauna in general, but the fact that species of fish and plants which characterize the typical Catskill rocks have been found in strata having Chemung fossils above them, makes it impossible to locate the precise equivalency of rocks marked only by the one or the other of these types of fossils."† In another publication professor Williams has written more fully upon this topic and the following quotation gives a good idea of his views at that time. "In regard to the Catskill group, my studies have led me to believe that the Catskill red rocks of the east offer evidence of having been contemporaneous with a great portion of the Upper Devonian rocks, and a comparison of faunas, at least, goes to show that the base of the red beds does not form a definite and uniform horizon.... This shutting off of the sea [with its Chemung marine fauna] took place earlier in the eastern than in the western part of this New York-Pennsylvania area, and there is reason to believe that in Sullivan county, New York, it was as early as the reign of the Hamilton faunas."‡

My field studies, the past summer, in the eastern Catskills of Ulster and Greene counties, New York, have shown the correctness of the last sentence in the above quotation. In that region, along the line of the Ulster and Delaware R. R., the last marine fauna is composed principally of Hamilton species, above which are fossil plants of Hamilton facies; then non-fossiliferous shales and sandstones in which the first of the reds appear; still higher arenaceous shales and sandstones in which species of *Archæopteris* occur; and at the "Summit" gray and red sandstones, with some pebbles, but no fossils. Fifteen miles northeast, a section along the Kaaterskill creek and up Round Top mountain agrees in general with the above section; but, differs in having a great devolopment of massive conglomerates and also the *Archæopteris* zone was not noticed. At the Great falls§ of the Kaaterskill are numerous

*Proc. Am. As. Adv. Sci., Vol. XXXIV, 1886, p. 234.

†American Geologist, Vol. II, 1888, p. 241; or, Reports of the Amer. Comm. to the London Session of the Int. Cong. of Geologists, Pt. C, p.19.

‡Bull. U. S. Geol. Surv., No. 41, 1887, p. 27.

§These falls, which are also known as High falls and Big falls, are between three and four miles down the creek from Palenville.

specimens of *Spirifera granulifera* Hall, *S. medialis* Hall,* *Chonetes coronata* (Con.) Hall, and other characteristic Hamilton species; above this the blue flagging stone; then blue and gray, with an occasional layer of red to Palenville, at the entrance of the Kaaterskill Clove; in the Clove layers of reds alternating with grays predominate, but also some of blue and green occur, and in the lower portion of the glen are the fish beds of Sherwood;† then massive conglomerates alternating with grays and reds; and finally, forming the upper part of Round Top, principally coarse gray sandstones, which Hall and Ashburner called Pocono.‡ Near the foot of the Cascades below Haines' falls, and about four hundred feet below the base of the heavy conglomerate, so well exposed in Twilight park, in one of the bluish-gray arenaceous layers, are numerous specimens of *Psilophyton princeps* Dn.§ This horizon is several hundred feet above the top of Sherwood's fish beds and consequently would be in the midst of undoubted Catskill as defined by professor Hall.[1] In this great thickness of rocks[2] careful search failed to reveal any fossils, except the fish

*Prof. Davis in 1883 stated that "*Spirifer mucronatus* and *medialis* are both of common occurrence" at this locality (Bull. Mus. Comp. Zoölogy, Harvard College, Geol. Ser., Vol. I, p. 318).

†Proc. Am. Phil. Soc., Vol. XVII, 1878, p. 346. In connection with this section see Ashburner's interpretation in 2d Geol. Surv. Penn'a. F, 1878, pp. 218, 219, and Prof. Hall's account in the 28th Rep't. N. Y. State Mus. Nat. Hist. 1879, pp. 14, 15.

‡Prof. Hall in Proc. Am. As. Adv. Sci., Vol. XXIV, 1876, p. 83, and 28th Rep't. N. Y. State Mus. Nat. Hist., p. 15; Ashburner in 2d Geol. Surv. Penn'a. F, pp. 218, 219.

§In order to remove any doubts as to the correctness of this identification specimens were submitted to Sir William Dawson, who wrote me March 19th, 1891, as follows: "So far as I can make out, most of the plants are *Psilophyton princeps*. One seems to have sporocarps attached, and the broader stems are, I suppose, rhizomata....

As to the age of your specimens,—though *Psilophyton* occurs in the Upper Devonian, I have not found beds so exclusively filled with it as yours seem to be, except in the middle or lower division. Perhaps it held out longer further south, like some other plants."

[1]See Proc. Am. As. Adv. Sci., Vol. XXIV, 1876, p. 83, where Prof. Hall stated that "The occurrence of this fossil [*Cypricardites catskillensis*] may, in my opinion, be relied on as characterizing the base of the Catskill formation, while the *Holoptychius* marks the beds above, but still is not known above the middle of the formation." While in 1879 Prof. Hall in describing this particular section said "On the eastern face of the Catskills, in the gorge known as the Clove, the same beds [Catskill] have been recognized charged with the remains of *Holoptychius*, similar to those of the beds near Blossburgh, Pa., and elsewhere" (28th Rep't, N. Y. State Mus. Nat. Hist., p. 14.)

[2]Sherwood's measured section from Palenville to the summit of Round Top is 3,482′ (Proc. Am. Phil. Soc., Vol. XVII, pp. 346, 347); while Prof. Hall in discussing it said "The section measured from Palenville,

fragments and plants, above the fauna first mentioned, which is regarded as probably belonging to the Hamilton stage and certainly is not later than the fauna of the "Ithaca group."

In the preparation of that portion of this paper relating to the range and distribution of the fossil plants, I would acknowledge great assistance from data contained in the Division of Paleobotany of the U. S. Geological Survey, which Prof. Lester F. Ward has kindly placed at my disposal.

U. S. Geological Survey, March 1891.

NOTES ON THE GEOLQGY OF THE SOUTHWEST.

By Robert T. Hill, Austin, Texas.

Thickness of the Upper Cretaceous Marls.—It is impossible, owing to the softness and lack of good exposures, to measure by surface sections the thickness of the upper Cretaceous beds in central Texas. An artesian well at Thorndale, however, penetrated 2000 feet of the Glauconitic beds and Exogyra ponderosa marls.

Foraminifera of the Texas Region. There is a fertile field for study on the micro-paleontology of the upper and lower Cretaceous beds of Texas, and some of the Foraminifera are most interest ing. I have recently seen a beautiful Rotalia from the uppermost upper Cretaceous, collected by Mr. J. S. Stone, while the Austin and other chalks are abundant in undetermined forms. The *Nodosaria texana*, of Conrad, belongs to the Denison beds and their southern continuation—the Exogyra arietina clays. This form literally composes great masses of limestone west of El Paso, at Del Rio and other points on the Pecos region of Texas. I have also found it at Roanoke in northern Texas in the the ferruginous sands of the Denison beds. Another form, the *Tinoporus texana*, of Roemer, occurs as the substance of a beautiful chalk stratum

in Green county, to the top of Round Top mountain, gives an entire thickness of nearly 3,800'" (28th Rept. N. Y. State Mus. Nat. Hist., p. 15.) The sum of Ashburner's totals, for the several subdivisions of this section, is 3,939'; but, the thickness of the red beds is 1,889' instead of 2,319' as given by him and in addition he counted the 27' of bed No. 145 twice (2d Geol. Surv. Penn'a. F, pp. 218, 219.) The entire thickness of the series under consideration, extending from the top of the Hamilton group to the summit of Round Top, was estimated by Prof. Hall to be 5,800' (Proc. Am. As. Adv. Sci., Vol. XXIV, pp. 82,83.)

in the alternating beds of the Trinity division of the Comanche series, and a suite of specimens has recently been forwarded to Washington for the educational series of the U. S. Geological survey by Mr. Wilson Davidson. European friends inform me that this form is very characteristic of the Aptian horizon of that country. The most remarkable foraminifer of the Comanche series, however, is the large strawberry-shaped form which I described lately in the *American Journal of Science*, which occurs associated with the last mentioned species in greatest abundance. I am informed by friends at Göttingen that this is a new genus. I shall be glad to aid any student who will undertake the systematic study of the Foraminifera of the Cretaceous beds of Texas.*

Recent Indian Work-Shops of Central Texas. No country can present such ideal conditions for aboriginal nomadic existence as the lower Cretaceous hills of central Texas, and here the Comanches, Huecos, Lipan and Kiowas for many centuries lived what must have been a most perfect savage life. In these plateaus and mesas is an extensive development of flint nodules, a clear, translucent variety, resembling in every lithological aspect the Cretaceous flints of Europe. The region has many springs and water holes, and near any of them can be found work-shops where the Indian manufactured spear and arrow heads. The prevalent method seems to have been to rudely fashion the nodules into "turtle backs" at the flint beds usually near the escarpments of the mesas, and then to convey their unfinished products to the water holes where they could be finally shaped at leisure.

Near an old Comanche trail in western Travis county nearly every flint seems to have been broken or tested, and numerous "failures" are found which the old school archæologist would vow are perfect types of European paleolithic implements.

I have obtained numerous evidences that their implements were manufactured in this century, not only from the fact that the implements are always on the surface and never buried but from ocular witnesses to the fact that the Comanches and other tribes actually used them in their warfare with the white men.

The Tertiary basin of the Lower Rio Grande. I have recently devoted much time to the study of the faulted mountain structure

*It will be gratifying t othe friends of science to know that Prof. W. B. Clarke of John Hopkins is undertaking a systematic study of the North American Cretaceous Echinodermata. Not a single group of our magnificent Cretaceous fauna has as yet been presented in a systematic manner.

and intervening Tertiary basins of the Texas-Mexican region. From San Antonio westward to Del Rio, and thence southeastward through Mexico to an indefinite distance coastward beyond Lampazos, Mexico, included between the eastward escarpment of the Comanche series plateau of Comal, Uvalde, Medina and Maverich counties and the Santa Rosa mountain group of Mexico, at an elevation of 400 to 1000 feet above the Rio Grande, there are preserved many remnants of a grand detrital deposit of either a fresh water lake or a great embayment of the gulf which existed in comparatively recent Tertiary or Quarternary time. This deposit is composed of flint and limestone pebbles and boulders of material, mostly from the Comanche rocks, cemented by a calcareous matrix. Terraces, benches and remnental patches of this material are found around the perimeter of the whole area in great thickness, while estuarine embayments extend far up the cañons of the streams flowing into it from the mountain. The cañon Rio Frio in Uvalde county, Texas, for instance, gives a fine view of this fact. While the headwater erosion of that stream is still progressing, and destroying the grand Cretaceous plateau of Edwards and Uvalde counties, the lower half of the cañon, from one to three miles in width, is a level valley filled with fifty feet of this ancient debris, through which the stream is now cutting. I propose the name Uvalde formation for this terrace and shall discuss it more fully in future papers.

The Age of the Strata at Marble falls and Shinbone ridge. In the AMERICAN GEOLOGIST for November 1889, I published a paper entitled "A Portion of the Geologic Story of the Colorado River of Texas," in which I assert the rocks of Marble Falls and the adjacent Shinbone ridge in Burnet county, Texas, to be of Carboniferous age. Inasmuch as my determination of the fossils were made by professor H. S. Williams of Cornell University, who is our best American authority on the later paleozoic rocks, I was somewhat surprised to read in Dr. Theodore B. Comstock's paper on the "Geology of the Central Mineral District" in the First (Second) Annual Report of the Texas State Geological Survey, that he had proved "beyond all doubt" that my conclusions were wrong, and that the strata at Marble falls were "Devonian" and those of Shinbone ridge "Silurian." Inasmuch as he gave no paleontologic or other reasons for this remarkable diversity in age of the same stratum, I recently revisited the region in company

with Dr. Cooper Curtice of the U. S. Geological Survey, and verified my observations by collecting a large and abundant fauna of typical Carboniferous forms at both localities, which are one and the same stratum, including Zaphrentis, Productus, and other typical Carboniferous species, all of which are on deposit in the Smithsonian Institution, where they can be seen. I shall be glad to furnish specimens of this fauna to all interested. Dr. Comstock also kindly remarks that I "hit" upon the age of the adjacent Burnet granite. Possessing the average amount of that humanity which is liable to err, especially in the study of those geologic specialties which are beyond my own narrow branch of the science, I must confess that the age of the Burnet granite is the only "hit" in the above mentioned paper wherein I missed, for I have since found that the overlying and contacting Potsdam sandstone is largely composed of this granite's debris, quartz, and feldspar and that Walcott's original determination of the pre-Potsdam age was correct.

Æolian deposits of Eddy county, New Mexico. The main western escarpment of the great mesa of the Llano Estacado is about fifty miles east of the present channel of the Pecos river, which has cut down through the fine clays and sands of the Red beds (Permo-Trias) and is blowing at this contact with the hard Permian limestones. The prevalent winds in this extremely arid region are from the west, and the fine sandy debris of the Red beds is blown eastward until its course is obstructed by the western escarpment of the Llano Estacado, where it forms a long strip of almost impassable sands 100 miles long by ten miles wide. So excessive is this wind erosion in the New Mexican portion of the Pecos valley, that sand storms are very prevalent, and I saw nearly ten bushels of fine sand swept from a large veranda as the accumulation of twenty-four hours time.

Possible Uses of Lignite.—The manufacture of the woody, fibrous lignites of the Eocene beds of Texas into briquettes is the subject of great discussion in Texas at present. That this cannot be done profitably owing to cost of manipulation has been proven by the extensive experiments of the Houston and Texas Central railway company. But there are other uses to which this inexhaustible mass of fuel can be put. Burned *in situ* the energy can be converted into electrical force and transmitted cheaply for industrial use. "Artificial natural gas," or water gas can also be

manufactured with it and piped to leading industrial centers at trivial expense. Already large quantities are being utilized as a substitute for charcoal—which it nearest resembles in physical properties—in the refinement of sugar.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The iron ores of Minnesota. Their discovery, development, qualities and origin, and comparison with those of other iron districts; with a geological map, 26 figures and 44 plates; 430 pp. 8vo. By N. H. and H. V. WINCHELL, Minneapolis, 1891. (The Geol. and Nat. Hist. Sur. of Minn. Bulletin No. 6.)

This is a work which was instigated by the law of 1887, requiring the state geologist to make special examinations for the discovery of any economic product, as the preface informs us, and certainly the authors have no need to apologize for not having sunk the appropriation in holes in the ground designed to lay bare parts of strata that have not been seen before.

The information contained in this volume is of far greater value than the discovery of a new bed of iron ore would have been, because it gives the most valuable information not only to the statistician, statesman, furnaceman, and miner, but especially to the class to which all of the above come for the information which they apply to economical work—the class of scientific geologists.

This work is comprehensively arranged into eight parts and four Appendices of which Part I contains all of the valuable new research and the rest is devoted to history, statistics, speculations, and lists. Nevertheless, so naturally do these latter follow the more original research of the first part, and so exhaustive is their treatment of the various subjects that they may also be said to directly contribute to our knowledge.

Especially is this true of Part IV which is concerned with the origin of iron ores; Part V, the bibliography of this subject with full citations from all who have entered this field of theory; and Appendix A which is a disquisition favoring the theory of the precipitation of the Keewatin ores and their distribution as a sediment, in opposition to a metasomatic genesis.

The 41 plates, including colored lithographic representations of thin sections of rocks, photographs of scenery, machinery, etc., maps and tables are admirably executed and worthy of the book which marks an epoch in this kind of work.

A hurried glance at Part I, which has the strongest bearing on the future iron industry, shows that it is divided into seven sub-headings following a sketch which shows the "recentness" of the development of the Minnesota ores.

The key-note of the interesting discussion of the Vermilion and Keewatin ores is contained in the statement that the Vermilion magnetites are embraced in the schists immediately superimposed upon the Laurentian gneiss. They are believed to be due to hydro-thermal forces acting within the earth's crust on sediments and iron ores which were nearly in the condition of the rocks of the Keewatin series which is that next following the Vermilion. This fact is assumed, and the following comparative tables of the constitution of the Keewatin and Vermilion rocks open the subject.

Keewatin.	*Vermilion.*
A chloritic mineral.	A horblendic mineral.
A sericitic mineral.	A micaceous mineral.
A feldspathic mineral (generally plagioclase).	A feldspathic mineral (frequently orthoclase).
Hematite iron ore.	Magnetite iron ore.

Good reason is shown for supposing that the change from chlorite to hornblende may take place by the loss of water and the absorption of lime. The evolution of the Vermilion biotite through hydrobiotite, and hydromuscovite, to muscovite are ascribed to hydrothermal action. The change from plagioclase to orthoclase is accounted for by heated alkaline solutions reaching the mineral while under partial or complete hydrothermal fusion. That magnetite can result from hematite through the agency of heat and moisture is taken as one of the commonest phenomena of metamorphism.

The Keewatin rocks are defined as of original volcanic origin as tuffs, altered and deposited by the hot Keewatin ocean.

A description of diamond drill holes near Tower, shows the frequent alternation of the schist with the ore and jaspityte. A well executed plate of four colored sections represents the studies of Dr. Hensoldt of some of these rocks.

But the main point contended for, viz: that there has been a completed cycle of evolution of the Biotite through Hydrobiotite to Muscovite and back again to Biotite, that the Keewatin type has changed to the Vermilion and back again to the Keewatin by the recurrence of similar agencies, is a strong corroboration of the theory of cyclomorphism which was emphasized in a paper read before the British Ass'n in 1888 entitled, "The nucleal ranges of the Antilles," wherein it was shown that just such complete cycles of change had been passed through by the crystalline rocks of Cuba.

It is interesting in this connection to note the correspondence of the association of red and purple jasper nodules occurring throughout the green schist with the same phenomenon described by the writer in the geological survey reports of Penna. and named by him "Mountain Creek rock," because found abundantly along the Mountain creek of South mountain in Cumberland, Adams, Franklin and York counties, Penna. In this latter region the average size of these fragments is much less than in Minn., but occasionally there would be found a mass several feet in diameter. It was found also impossible to draw a distinction in age between the red and amethyst (or purple) quartz fragments and the

enclosing schists. The significance of the analogy is that if the writer's structure of the South mountain be correct, these "quartz conglomerate schists" (as they are also called by him) represent the lower or nucleal anticlinal of the complicated series of folds representing this mountain chain and were considered as immediately overlying the Laurentian (See Reports 2d Geol. Survey of Penna. Vols. C 2, C 3, and C 4). In Pennsylvania, however, they were not associated with iron ores. Both specularite and native copper, however, are associated on the East flank of this mountain with chlorite schists and thin beds of the rocks named jasper by H. D. Rogers, and shown by Hunt to consist of a paste of orthoclase mingled with extremely finely divided quartz grains. The correspondence between these phenomena in the Vermilion range in Minnesota and the oldest part of the Appalachian system in Pennsylvania is of great interest.

A strong case is made for the distinction of two periods of brecciation of the jaspilyte. The first period being at or about the time of the production of the ore and jaspilyte and the second being with much show of reason ascribed to primordial time.

Dr. Hensoldt's argument in favor of the precipitation origin of the jaspilyte deserves to be well considered, but in view of the very important bearing the question of genesis has on a large series of rocks in the East it should be passed through the probation of criticism before it is finally accepted.

His plea is in short that under a moderate magnification this rock constituent exhibits the "mottled" appearance peculiar to novaculyte and hot-springs deposits. He finds in the quartz of the jaspilyte the same diversity in color with rotation around an axis, and the same absence of fluid enclosures as in the well known deposits of amorphous silicas.

He finds, however, a difficulty in the comparative uniformity and more or less hexagonal outline of the grains. His conclusion is both plausible and bold. He imagines a series of volcanic irruptions under a hot and dense sea-water charged with free hydrochloric, sulphuric and other acids. The iron of the magnetite in these lavas was, by reason of its greater specific gravity, first deposited as a fine mud, and following this the silica was deposited in drops as gelatinous silica. These drops pressing upon each other effected the "hexagonal outlines" as is the case with basaltic columns. The salts of calcium and magnesium being of low specific gravity were transported elsewhere. He further supposes that there was usually a cessation of the deposit of the jaspilyte while the materials of the green schist were being thrown down, but that occasionally they were thrown down together; and that after the deposit of a few thin beds these were disrupted and contorted before the formation of the next succeeding bands. His hypotheses are ingenious but cannot be said to be fully satisfying.

The authors feel justified in announcing that from the widest comparison of all the available data concerning the Keewatin and other ores "the Keewatin ores of Minnesota as produced from the mines at Tower

and Ely are purer than any ores mined to any extent in the world." This is based upon the fact that one-half the ore mined is low in phosphorus, and nearly one-half contains over 65 p. c. metallic iron and less than 0.06 p. c. phosphorus. The other half is not quite up to Bessemer standard, but its grades are guaranteed to run as follows: Vermilion, 66.66 p. c., Soudan, 65. p. c. and Red Lake, 62. p. c. metallic iron.

This is a great showing taking into consideration the high authority which is responsible for it.

In the consideration by the authors of the origin of the Keewatin ores (p. 105), there is a contradiction of the conditions supposed by Dr. Hensoldt in explaining the deposition of the ores (p. 75). In the latter he speaks of the heated waters of an ocean heavily charged with hydrochloric, sulphuric, and other acids, whereas the authors in the first citation supposed the volcanic outburst to come in contact with heated "*alkaline*" waters.

In the explanation (p. 110) of the abundance of iron and silica the authors say "these two minerals would have been the first to free themselves from solution and appear as precipitates on the bottom of the sea." This does not, however, explain why such a base and such an acid should not, in the poetic language of the previous page, have each taken the partnerless other and descended to the bottom so conjugated that their exploitation as silicate of iron would not to-day be a remunerative enterprise. If it is answered that the form of iron which was ejected by the submarine volcano was Fe. (Fe O 2). Still a little less than 25 p. c. of all the iron thus released would be like the silicic acid in the nascent state and in the most favorable condition to combine. Yet there is no record of any large percentage of iron silicate among these deposits.

A similar origin is supposed for the Taconic as for the Keewatin ores.

In the synoptical review the presence of titanium is taken in the ores of the Vermilion series to indicate an early eruptive origin of the ore, and the Vermilion itself as upper Laurentian. The Keewatin ores are the chronologic equivalent of the ores of the Laurentian gneises of the eastern border. The Taconic (Huronian) ores consist of non-titanic magnetites at the bottom, jaspilitic hematites next above, soft hematites, and titanic magnetites. The Cretaceous limonites are unimportant in Minnesota.

The careful compendium of views on the origin of iron ores does great credit to the industry and conscientiousness of the authors. Few subjects have ever received such a thorough treatment. Besides a classification of eighteen theories of the origin of iron ores and a tabular statement of the geologists who have favored each theory, there is at the end a digest of the views of geologists from the earliest times in alphabetical order, occupying 72 pages and containing all of importance that has been written on the subject.

Appendix B is a reprint of a paper read before the Geological Society of America on the Taconic Iron ores of Minnesota and western New England. Appendix C is a recent paper by the state geologist of Minnesota before the Minnesota Academy of Natural Sciences.

The whole volume is an enduring monument to the ability and faithfulness of its authors, and one of the best examples in the language of how such a work ought to be done to conform to the demands of the State and to satisfy the expectations of scientific men. F.

Summary report of the Geological Survey Department (Canada) for the year 1890. Octavo, Ottawa, 1891, pp. 57. By ALFRED R. C. SELWYN, *Deputy head and Director.* This gives the law of the new organization of the survey as a department of the civil service, and a brief summary of the operations of the fourteen parties which carried on the fieldwork during the season of 1890.

We note in Mr. Tyrrell's report on northwestern Manitoba the discovery of a phosphatic shale in the Niobrara formation containing 17.25 per cent. of phosphoric acid, composed largely of fragments of fish remains. He also identifies the Pierre shales and the Benton formation. Niagara was found on the shore of Cedar lake, but on lake Winnipeg the Trenton and Utica formations only exist. The St. Peter sandstone of Minnesota, and the Keewatin series of schists of the Lake of the Woods district were identified. One of the important results in Manitoba is the discovery of considerable deposits of amber on the west shore of Cedar lake mixed loosely with sand and many fragments of partly decayed wood, on a low beach. It constitutes from five to ten per cent. of the volume of the whole deposit, and is estimated to amount to at least 1.457,280 pounds. From the Dakota sandstone at Morden a flow of salt-water was obtained at the depth of something less than 600 feet. The expenditures of the survey for the year ending June 30, 1890, were $102,864.99.

A new basis for Chemistry; a chemical Philosophy. By THOMAS STERRY HUNT. Third Edition, with new preface, 12mo. Scientific Publishing Co., New York, 1891.

For more than forty years Dr. Hunt has held a conspicuous position among the chemico-geologists of America, and his late works, which are the culminating results of long researches, embody the conclusions of his life-work. These convictions, however, so far as they fall into the sphere of this volume, were many of them announced, though not with full elucidation and demonstration, over thirty years ago. Since then great advances have been made in dynamical and chemical knowledge, and this little volume is a re-embodiment, with additional philosophical discussions, of principles which were announced from time to time in the scientific journals, since 1848.

On the Biological and Geological Significance of closely similar Fossil Forms. By DR. C. A. WHITE, U. S. Geological Survey. (Proc. A. A. A. S., Vol. XXXIX, pp. 239-243.)

In the study of fossil molluscan faunas it is frequently found that a few apparently identical or closely similar forms occur in formations widely separated, both in time and space, while the accompanying faunas have no other species in common. Of these forms the greater number are monomyarians, though there are also many heteromyarians and

some land and fresh water bivalves and univalves. For example: Ostrea diluviana Linn. from the Turonian of Europe, an Ostrea to which the same name has been given from the Lower Cretaceous Comanche series of Texas, O. barrandei Coquand and O. dilleri White from the Upper Cretaceous of New Jersey and California, respectively, are all so closely related in form that their differences are not greater than the individual variations usually seen in the species of this genus. The associated forms are all distinct. Several other examples are cited among Ostreidæ, Aviculidæ, Unionidæ and other families, in some of which the forms are separated by much greater time intervals.

The method of treating such forms will depend largely on the character of the work that the paleontologist has in hand and on the relative importance that he gives to the geological and the biological sides of his subject. If the investigation is purely biological without reference to geographical or geological distribution, these closely related forms are naturally regarded as belonging to the same species and are called by a single name. If, on the other hand, fossils are studied as an aid in describing and characterizing geological formations, and a given formation yields a fauna made up of species peculiar to itself with the exception of a few such forms as those under discussion, it is held to be admissible to treat the entire fauna as distinct and to give a new name to each species.

It is believed that this method of treatment will give better and more direct results in the classification of the formations of this continent, and in their ultimate correlation with those of other continents, than would one in which biological ideas predominate. The synonyms that may be thus introduced are regarded as of little consequence compared with the resulting advantages.

Glacial Lakes in Canada. By WARREN UPHAM. Bulletin of the Geological Society of America, vol. ii, pp. 243-276; March 5, 1891. A glacial lake, according to the use of the term in this paper, is a body of water bounded in part by a barrier of land-ice, as the Merjelen see of the present day and lake Agassiz in the closing stage of the Glacial period. The evidences of the former existence of glacial lakes, pent up in valleys and basins which had descending slopes toward the ice-sheets during their final recession, are comprised in five classes: (1) channels eroded by streams outflowing from the glacial lakes across the present great lines of watershed; (2) low cliffs eroded along the lake shores, commonly consisting of till; (3) beaches of gravel and sand, often reaching continuously in a wave-formed ridge along a distance of many miles; (4) deltas of gravel and sand, brought into the edge of the lake by tributary streams; and (5) finer lacustrine sediments, brought mainly by the same tributaries and spread over the lake-bed beyond the deltas, but in part supplied by wave-erosion of the lake shores.

The principal glacial lakes of Canada are noticed in geographic order from west to east. In British Columbia the "White Silts," described by Dr. George M. Dawson as occurring up to altitudes of 2,300 to 2,700 feet, and by him referred to marine deposition, are regarded by Mr.

Upham as sediments laid down in glacial lakes or on land areas across which the floods discharged from the melting ice-sheet flowed away on their course to the sea. Glacial lakes in the basins of the Peace and Athabasca rivers, and of the Saskatchewan and Souris rivers, are shown to have been tributary to lake Agassiz, which covered the valley of the Red river of the North and the low area of Manitoba, being still represented there by the large lakes Winnipeg, Manitoba, and Winnipegosis, besides others of smaller size. The area of lake Agassiz is stated to have been about 110,000 square miles, or more than the combined areas of the five great lakes which outflow by the St. Lawrence. Its highest shore, marked by beach ridges and rarely by low eroded cliffs, Mr. Upham has traced with levelling along an extent of about 600 miles across the southern prairie portion of its area; and Mr. J. B. Tyrrell has extended this examination about 100 miles farther north along the escarpments of Riding and Duck mountains. The great Laurentian lakes were also held at much higher levels than now by the barrier of the waning ice-sheet, and the Canadian shores of these enlarged lakes are very distinct in many localities north of lake Superior, about lake Huron, and in the vicinity of Toronto.

From surveys by Gilbert, Spencer, and others, the elevations of the highest glacial shore lines about the Laurentian lakes, especially lake Ontario, have been ascertained continuously through long distances. It is thus found that since the departure of the ice-sheet portions of this lake area have undergone a differential uplifting, of increasing amount from south to north and northeast. The maxium rate of northward ascent of the old beaches is adjacent to the eastern end of lake Ontario, being about 5 feet per mile through a distance of more than fifty miles. On the area of lake Agassiz, however, where northward uplifting had been previously discovered by Mr. Upham, the ascent, which is continuous along a distance of at least 400 miles from south to north, varies from a minimum of about six inches to a maximum of only about one and a half feet per mile. The levels of the Laurentian lakes in the Champlain epoch, or time of recession of the latest ice-sheet, and the contemporaneous sea level which reached along the St. Lawrence valley to Ogdensburgh and Brockville, near the mouth of lake Ontario, with the changes produced by the uplifting of the land shown to have been then in progress by successive beach lines, lead Mr. Upham to the conclusion that the altitude of the glacial outlet from lake Michigan to the Des Plaines river at Chicago has remained nearly the same from the Champlain epoch to the present time, while the northern and northeastern part of the area of the Laurentian lakes has been elevated 300 to 500 feet during and since that epoch.

The latest North American ice-sheet, by which these glacial lakes were formed at the time of its recession, is shown by Mr. Upham to have probably been during its culmination of greatest extent and depth a continuous *mer de glace* from the Atlantic to the Pacific, overtopping the Rocky mountains in the Peace river region, and outflowing from the interior portion of its area both southward and northward. The thick-

ness of its central belt from Labrador and the south part of Hudson bay westward to the Pacific varied apparently from one to two miles, and the area which it covered was approximately 4,000,000 square miles.

Stratigraphy of the Carboniferous in central Iowa. By CHARLES R. KEYES. Bulletin, G. S. A., vol. ii, pp. 277-292, with two plates; March 5, 1891. A section extending 65 miles, from Harvey in Marion county west-northwest along the Des Moines river to the city of Des Moines and thence westward along the Raccoon river to De Soto, is here delineated; and descriptions of the strata are given for the ten localities included within this distance. There is in general a very gentle dip toward the southwest. Mr. Keyes finds from careful measurement of the various members of the Lower Coal Measures, that they originally were more than 700 feet thick; but they have suffered much erosion, and probably nowhere in this district present now so much as half of this thickness. They are chiefly shales, with infrequent and thin layers of sandstone. One exceptional bed, however, called the Redrock sandstone, has a length of at least twenty miles and a width of six or seven miles, and attains a maximum thickness of more than 150 feet. Only a few very thin bands of limestone, mostly nodular and shaly, are found; but, though seldom exceeding ten or twelve inches in thickness, they constitute the most persistent horizons of the series, being recognizable over wide areas.

The coal seams vary from a few inches to seven or eight feet in thickness, the average of those at present worked being between four and five feet. They occur as lenticular masses, from a few hundred yards to several miles in diameter; and along the line of this section more then twenty coal-bearing horizons have been found, some of them having several of these lens-shaped layers of greater or less extent. The fauna of the section embraces about 50 genera and more than 150 species. Minute molluscan shells occur in vast numbers.

Evidence of important oscillations of level during the deposition of the Lower Carboniferous formations and the Coal Measures is shown by unconformaties, some of which were reported by White more than twenty years ago. The most remarkable instance is the erosion of the Redrock sandstone in deep gorges and ravines, which afterward became filled with a coal deposit and shales.

An introduction to the study of petrology: The igneous rocks. By FREDERICK H. HATCH, PH. D., F. G. S., 43 illustrations, 12mo., 128 pp., New York, Macmillan & Co., 1891.

This is a handy compend of the characters of igneous rocks, as well as of the minerals of which they are composed. Its use presupposes a knowledge of all the customary methods of determination whether they be chemical or microscopic. It has chapters on their structure, chemical composition and alteration, as well as on their classification and distribution in the British Isles. The work does not afford extensive references to literature, but it is evidently based on a wide acquaintance with the best authorities. It is adapted to beginners.

The Chazy formation in the Champlain valley. By EZRA BRAINERD. Bulletin, G. S. A., vol. ii, pp. 293–300, with one plate; March 17, 1891. This paper gives details of seven sections of the Chazy formation, as it is found (1) on Valcour island; (2) in the township of Chazy, N. Y.; (3) on Isle La Motte; (4) in Highgate, Vt., and St. Armand, Que.; (5) in Cornwall, Vt.; (6) at Crown Point, N. Y.; and (7) in Orwell, Vt. The formation attains its maximum observed thickness on Valcour island, situated about six miles south of Plattsburgh, N. Y., which seems to have been hitherto unexplored by any geologist. According to exact measurements the Valcour section displays an aggregate thickness of 890 feet of Chazy strata which are classed under three divisions, named the Lower, Middle and Upper Chazy. The thickness of the lower part is 338 feet; of the middle, 350 feet; and of the upper, 202 feet.

The Mesozoic and Tertiary Insects of New South Wales. R. ETHERIDGE, *Jr.*, and A. SIDNEY OLIFF. This paper is No. 7, Palæontological Series, of the Memoirs of the Geological Survey of New South Wales. In it we have described and figured five species of fossil insects collected from three localities and probably two geological horizons in Australia. So far the palæozoic strata of Australia have furnished no remains of insects. For some time a Libelluloid wing from beds of the Cretaceous period was the oldest known representative of Australian insect life. This wing, together with a few Tertiary fragments, chiefly elytra of beetles, represented all that was known of the fossil insect faunas of Australia prior to the publication of the present memoir. In this memoir we have a cicada-like species, *Cicada ? lowei* described from strata, probably of Triassic age, occurring near the Talbragar river between Mudgee and Gulong. Of the remaining four species here described, a beetle referred to the family *Buprestidæ*, *Mesostigmoderma typica*, comes also from the lower Mesozoic, but from the Ipswich Coal Measures at Denmark Hill, Ipswich, Queensland. The other three species occur in a species of bog-iron ore that partly occupies an old silted up channel cut in Tertiary lavas, and are associated with a flora of Tertiary age. The channels bearing the insect-bearing iron ore are worked for ores of tin which they contain. The locality is known as *The Vegetable Creek Tin-mining Field.* Two plates give excellent figures of the species described.

Records of the Geological Survey of New South Wales, Vol. II, Part II. 1890. We have in this publication a number of short papers, embracing results of observations made in connection with the Geological Survey of New South Wales. The titles include *The raised Beaches of the Hunter River Delta; The Shell-heaps accumulated by Aborigines of the Southern Coastal District; Some beautifully formed Stone Spear-heads from Kimberly; Notes on the Gunnedah Coal-field; On the occurrence of Fish Remains in the Rocks of the Drummond Range, Central Queensland; Description of Stone Weapons and Implements used by Aborigines of N. S. Wales;* and *Description of Two Undescribed Univalves from the Lower Carboniferous Rocks of N. S. Wales.* Among the plates is one

devoted to beautiful illustrations of the Kimberly spear-heads, reproduced by heliotype process from drawings made by Mr. G. H. Barrow.

A bibliography of palæozoic Crustacea from 1698 to 1889, including a list of North American species and a systematic arrangement of genera. By ANTHONY W. VOGDES. (Bulletin No. 63, U. S. Survey, 1890, 8vo. pp. 177.)

Captain Vogdes' long acquaintance with the literature of the trilobites and other crustacea has served to produce a very valuable aid to students of paleozoic crustacea, this bulletin serving them as a working hand-book and guide to the original literature. The trilobites are arranged into 81 genera. The author enumerates 682 species, and gives a systematic classification of the eighty-one genera, which he arranges in alphabetic order giving references to all the specific descriptions.

The **LOWER TACONIC** is represented by the following genera: **Olenellus**, **Agraulos** *strenuus*, Atops, **Ellipsocephalus**, Bathynotus, Protypus, **Liostracus**, *Ptychoparia adamsi*, *P. fitchi*, *P. misera*, *P. sub-coronata*, *P. teucer*, *P. vulcanus*, *etc.*, **Agnostus**, *nobilis*, *A. interstrictus*, *A. desideratus*, Microdiscus, Avalonia, Oryctocephalus *Zacanthoides spinosus*, *Z. typicalis*, *Solenopleura bombifrons*, *S. nana*, *S. harveyi*, *S. howleyi*, **Anomocare** (?) *parvum*; in Newfoundland, Canada, Vermont, New York, Nevada and Utah.

The 2d fauna, or *Paradoxides* zone, appears in Newfoundland, Massachusetts and New Brunswick; it contains the following genera: **Paradoxides**, *Agraulos affinis*, *A. socialis*, **Liostracus** *tener*, *L. ouangondianus*, *Ptychoparia*, *linnarssoni*, *etc.* **Solenopleura** *bombifrons*, *S. communis*, *S. robbii*, *S. acadica*, *Agnostus acadicus*, *A. regulus*, *A. partitus*, *A. vir*, *A. tessella*, *A. umbo*, *A. obtusilobus*, *A. acutilobus*, *etc.* **Conocoryphe** *baileyi*, *C. elegans*, *C. walcotti*, *Ctenocephalus* (*Hartella*) *matthewi*.

The **UPPER TACONIC**, comprising the 3rd or *Olenus* zone is only represented in America by *Olenus utahensis*, the 4th fauna or *Parabolina* and *Peltura* zones is not known in America. The Upper Taconic includes the *Olenus*, *Parabolina* and *Dikelocephalus* zones.

The fifth fauna, or *Dikelocephalus* zone is well represented in the Quebec group of Canada, also in Wisconsin, Nevada, Utah, Texas, etc.; it contains the following genera: *Anomocare*, *Bathuyrus*, **Chariocephalus**, **Dikelocephalus**, **Illænurus**, *Ptychoparia*, *etc.*

The following list gives a synopsis of the genera appearing in the Taconic, followed by a number of species in each genus. Aglaspis 2, **Agnostus** 26, **Agraulos** 13, Amphion (?) 1, **Anomocare** 6, Anopolenus 1, **Avalonia** 1, Arethusina 1, *Asaphiscus* 2, (and Bathyuriscus 3) 5, (**Atops 1**, *Dorypyge 4*, and *Olenoides 5*, *10*,) **Bathynotus** 1, Bathyurus 18 (?), **Conocoryphe** 8, (*Crepicephalus 5 ?*) Chariocephalus 2, Dikelocephalus 32, Dolichometopus 3, **Ellipsocephalus** 1, Illænurus 3, Lloydia 1, Menocephalus 4, (*Mesonacis* and **Olenellus** 7,) (**Microdiscus** 12 and *Pemphigaspis 1*, *13*,) Ogygia 5, **Oryctocephalus 1**, **Paradoxides** 12, **Protypus** 2, Pterocephalus 3, Ptychaspis 10, Ptychoparia 58, **Liostracus** 4, Shumardia 2, **Solenopleura** 9, Triarthrella 1,

Zacanthoides 4, **Olenus** 1, *Strenuella 2* including *Agnostus strenuus* and *Anomocare ? parvum*).

The **CAMBRIC** or Lower Silurian is represented by the following genera: Acidaspis 9, Agnostus 3, Agraulos 1, Amphion 8, Ampyx 6, **Asaphus** 27, Barrandia 1, Bathyurellus 9, Bathyurus 17 (?) Bronteus 1, **Calymene** 7, **Ceraurus** 18, Chasmops 1, Dalmanites 7, Dionide 1, Encrinurus 5, Endymionia 1, Harpes 6, Holometopus 1, Homalonotus 1 *Harpides 3*, **Illænus** 25, Lichas 6, Megalaspis 2, Nileus 3, Ogygia 2, Panderia 1, Proetus 2, **Remopleurides** 5, Sao 1, Sphærexochus 1, Sphærocoryphe 2, Symphysurus 1, Telephus 1, **Triarthrus** 5, **Trinucleus** 2.

SILURIC or Upper Silurian, Acidaspis 5, Bronteus 8, Calymene 8, Dalmanites 17, Cyphaspis 3, Encrinurus 8, Homalonotus 3, Illænus 14, Lichas 12, **Phacops** 6, Proetus 7, Sphærexochus 3, Ceraurus 2.

DEVONIC, Acidaspis 2, Bronteus 2, Cyphaspis 8, **Cryphæus** 4, Dalmanites 17, Homalonotus 4, Lichas 7, Phacops 6, Proetus 28, Phaethonides 4.

CARBONIC, **Phillipsia** 14, Phæthonides 4, **Griffithides** 6, Proëtus 9, **Bathymetopus** 1, Dalmanites (?) 1.

PERMIAN, Phillipsia 1.

The non-trilobitic genera and species are catalogued in the third part of the work. The author gives a systematic classification of the genera and catalogues 275 species under 65 genera as follows:

TACONIC, **Protocaris** 1, Leperditia 2, Aristozoe 2, Nothozoe 1, Beyrichona 2, Hipponicharion 1, Lepidilla 1, Lepiditta 2.

CAMBRIC or Lower Silurian, Æchmina 1, Aparchites 2, Beyrichia 18, Bythocypris 3, (*Cythere 1 ?*) (*Cytherina 3 ?*) (*Cytheropsis 1 ?*) Echinognathus 1, Entomis 1, Eurychilina 3, **Isochilina** 7, Leperditia 21, Lepidocoleus 1, Primitia 4, Strepula 2, Bollia 1.

SILURIC or Upper Silurian, Æchmina 1, Bairdia 1, Beyrichia 16, Bollia 2, Bythocypris 1, **Ceratiocaris** 6, Dolichopterus 1, **Eurypterus** 11, Klœdinia 2, Leperditia 15, **Pterygotus** 10, Macrocypris 1, Polycope 1, Bunodella 1, Primitia 2.

DEVONIC; Amphipeltis 1, Beyrichia 8, Bollia 4, Bythocypris 1, Ceratiocaris 3, Dipterocaris 3, Dithyrocaris 1, **Echinocaris** 7, **Elymocaris** 2, Entomis 2, *Estheria 1*, *Eurypterus 1*, *Isochilina* 2, Klœdinia 1, *Leperditia 4*, Lisgocaris 1, Moorea 1, Mesothyra 3, Octonaria 1, Palæopalæmon 1, Palæocreusia 1, Plumulites 2, Protolemulus 1, Primitia 4, Primitopsis 1, Protobalanus 1, Rhinocaris 2, Schizodiscus 1, Spathiocaris 1, Strobelepsis 1, Stylonurus 2, Strepula 2, Tropidocaris 4. Turrilepas 8, Ulrichia 1, Eurypterella 1.

CARBONIC, **Acanthotelson** 2, Anthrapalæmon 2, Archæocaris 1, Ceratiocaris 2, Cryptozoë 1, Cyclus 1, Cythere ? 6, Cytherellina 1, Dipeltis 1, Diplostylus 1, Dithyrocaris 1, **Estheria** 1, Eurypterus 5, Isochilina 1, **Leaia** 2, Leperditia 2, Palæocaris 1, **Prestwichia** 1, Rachura 1, Strigocaris 2, Belinurus 1, Beyrichia 3 Carbonia 3. (See note.)

In the supplement the genera Olenoides, Dorypyge and Angelin's Corynexochus in part are placed as synonyms of Atops of Emmons, the authority for this being Ford's figure of Atops trilineatus from Troy, N. Y.

The author has followed the various authorities in naming the stratigraphic groups to which the species are assigned. Hence appear some incongruities, since palæontologists have not been agreed as to what names should be used for the horizons to which their fossils belonged. Under the guide of palæontologic distinctions these anomalies can nearly all be eliminated now, and various zones can be defined having common characters, embracing several of the old names in one zone. The questions of nomenclature for these zones are complicated and vexatious; but it seems to become more and more appropriate that the rule of *priority* should be as binding in geologic stratigraphy as in zoölogy. With that as a guide many synonyms which now are in conflict and annoy the systematist, will drop out of the science.

NOTE. Recent investigation in Palæozoic Crustacea have added to the number of genera as follows:

Cambric.—Entomis 1, Pontocypris (?) 1, *Ctenobolbina* (n. g.) 6, *Tetradella* (n. g.) 6, Bollia 2, *Drepanella* (n. g.) 5, *Jonesella* (n. g.) 4, Placentula 2, Beyrichia 1, Eurychilina 7, Primitia 11, Aparchites 1, Leperditia 4, Leochilina 6. Total 57.

Siluric.—Entomis 1, Ctenobolbina 1, Aechmina 1, Octonaria 1, Bythocypris 1. Total 5.

Devonic.—Cytherella 1, Ctenobolbina 4, Bollia 2, Beyrichia 3, Aparchites 1, Leperditia 1, Aechmina 1, *Halliella* (n. g.) 1, Moorea 1, Kirkbya 3, Octonaria 5, Bythocypris 2, Bairdia 1, *Pachydomella* (n. g.) 1, *Barychilina* (n. g.) 3. Total 30.

Carbonic.—Phillipsia 1, Pontocypris 1, Bollia 1, Beyrichia 2, Primitia 5, Leperditia 1, Moorea 1, Kirkbya 5, Bairdia 1, Ulrichia 2, Cypridina 1, Cytherella 2. Total 23. Trilobites, 81 genera, 683 species. Palæozoic crustacea, 72 genera, 389 species.

Trionyx from Malta. In the Quart. Jour. Geol. Soc. Feb. 1891, Mr. Lydekker describes a new species of *Trionyx* (*T. melitensis*) from the Miocene of Malta. The species is represented by a portion of the carapace, which, as restored, is about twelve and one half inches long and about twenty inches across. The species closely resembles *Chitra indica* and the author is only prevented from placing it under this genus by the fact there is no known instance in *Chitra* of a divided first neural.

Palæosyops and Allied Genera, by CHARLES EARLE. (Proc. Acad. Natl. Sci. 1891, pp. 106–117.) This paper represents a considerable more comparison of the different species than has ever before been attempted; from this standpoint the paper is particularly valuable, if from no other. The author takes the trouble (?) to say that he has been able to compare the different specimens in the museums at Washington, Philadelphia, Princeton, and New Haven, in which he is most fortunate, as *Palæosyops* has been in a most mixed-up state ever since it was first described. The Princeton specimen of *P. paludosus* Leidy is made the basis of operations and, as the reviewer of this paper has said on former occasions, the work from the Princeton museum has been most satisfactorily done. Mr. Earle thinks Leidy's *P. major* is synonymous with *P. paludosus* Leidy; the specimens representing the former equalling in every particular the original specimens of the latter and hence he suppresses the species *P. major*. He has found two different individuals indicated as *P. paludosus* Leidy; to the smaller he applies the name *P. minor*, which no doubt equals some of Leidy's later *P. paludosus* but *not the original*. Cope's *P. lævidens* is dropped, as not appropriate. The

author also states Marsh's claim that the teeth of *P. laticeps* Msh. have the same structure as Leidy's *P. paludosus* is incorrect; the molar of the one approaches *Telmatotherium* Msh., the other *P. paludosus* Leidy. *Leurocephalus* S. & O. becomes a synonym of *Telmatotherium* Msh which is retained. Each species is then taken up and described in a comprehensive manner. *Palæosyops minor*, sp. nov. in which "second superior premolar with two external lobes; external lobes of last superior premolar equal. Intermediate conules of true molars reduced, a strong external cingulum present." *Limnohyops* Msh embraces *Palæosyops* as employed by Marsh, *Limnohyus* as employed by Leidy and others. *Limnohyops laticeps* Msh., syn. with *P. laticeps* and *Limnohysus laticeps* of Leidy. *Palæosyops megarhinus* Earle (Am. Nat. Jan. 1891, 45): "No diastema in superior dental series, canines very small and wide-spreading, superior true molars without external cingulum; distal extremity of nasal expanded."

Age of the Peace Creek Beds, Florida. Mr. W. H. Dall (Proc. Acad. Natl. Sci., Feb, 17th, 1891), calls these beds, from which a considerable number of mammalian fossils have recently been extracted, "Older Pliocene."

Basanite from the Wyandotte Cave. E. Goldsmith gives an analysis of basanite from Wyandotte cave, Crawford, Co., Ind.: SiO_2, 93.66; $Al_2O_3+Fe_2O_3$, 3.10; H_2O, 1.34; C, 0.28; Cl, Trace; Sp gr., 2.605. *Proc. Acad. Natl. Sci., Phila., 1891, p. 99.*

Dictionary of fossils.—By J. P. Lesley. (Geological Survey of Pennsylvania, P4, vol. ii, N-R, 1888, and P4, vol. iii, S-Z, 1890.

These two volumes are a great improvement over the first volume which contained no less than thirty pages of errata. Vol. ii contains ten and vol. iii, thirteen pages of errata. The labor involved in the production of this work cannot be overestimated, and while the dictionary is intended for the use of citizens of the state of Pennsylvania, it will undoubtedly prove more useful to the palæontologist, being, as it is, an alphabetical synopsis of the entire Palæozoic system in Pennsylvania and adjacent states. The work throughout is abundantly supplied with illustrations and it is to be regretted that they are not of better quality, but, however, it is understood that the appropriation by the state would not admit of better ones.

Contributions to Invertebrate Palæontology. R. P. Whitfield. (Annals N. Y., Acad. Sci. 5, Dec. 1890, pp. 505-622.)

Under this title Mr. Whitfield gives a very interesting description of a large number of species from the various horizons of the Palæozoic. Under "Fossils of the Erie Shales" is described a new species of Entomostraca *Aristozoe canadensis*, whose carapace is one and one-half inches long and one inch high. This, however, is not from Ohio, having come, it is said, from the Trenton of Canada. Twelve well-executed plates illustrate the paper.

CORRESPONDENCE.

LAKE SUPERIOR STRATIGRAPHY. In your May number Dr. Lawson has a criticism* of a recent paper of mine† in the American Journal of Science upon Lake Superor Stratigraphy, in reference to which I ask space for a few remarks.

In the first place, while Lawson mentions our past and present general agreement, he so emphasizes the points of difference that one would not become aware from the review how close this agreement really is. The district considered by Lawson is only one of several in the Lake Superior region which were discussed by me. If the criticisms were wholly true of that one district they would not disprove the correlations for the others. I am in harmony with, and understood before the appearance of the criticism, the four propositions‡ made as to the relations of the Animikie, Keewatin, Coutchiching, and the gneiss and granite which Lawson recognizes as Laurentian, except that I have no knowledge whether or not the pre-Animikie erosion is "the greatest in American Geology." From the criticism, although I do not suppose this was intended, one would certainly infer that there is a fundamental difference in the successions proposed by Lawson and myself. I submit a parallel arrangement of our stratigraphical columns for western Ontario, omitting major taxonomy.

Succession in western Ontario according to Van Hise.[1]	*Succession in western Ontario according to Lawson.*[2]
Nipigon.	Keweenawan or Nipigon group.
Unconformity.	Unconformity.
Animikie and Upper Kaministiquia.	Animikie Group. (Possibly Huronian).
Unconformity.	Unconformity—Greatest erosion interval in American Geology.
Keewatin in part at least, and Lower Kaministiquia.	Keewatin Group. (Possibly Huronian.)
Unconformity?	Unconformity?
Coutchiching.	Coutchiching Group.
Eruptive Unconformity.	Irruptive Unconformity.
Laurentian.	Laurentian System.

The rock succession is seen to be nearly identical, with identical relations. Lawson says that my table presents an "undesirable incongruity" in that the Laurentian rocks are made more ancient than the Keewatin, when they cut them. That I recognized that the granite-gneiss of Rainy lake and the Lake of the Woods cuts the Keewatin is

*Lake Superior Stratigraphy, Andrew C. Lawson: Am. Geol., vol. 7, pp. 320-327.

†An Attempt to Harmonize some apparently conflicting views of Lake Superior Stratigraphy, C. R. Van Hise: Am. Jour. Sci., vol. 41, pp. 117-137.

‡Ibid, p. 322.

[1]Ibid, p. 137.

[2]Ibid pp. 326-327. In this succession in the original table Irruptive Unconformity and Laurentian system are transferred under Coutchiching in order to give a columnar arrangement. The Irruptive Unconformity and Laurentian System in the table are so arranged as to apply both to the Coutchiching and Keewatin.

clearly indicated in the text of my paper.* Aside from the matter of the signification of Laurentian, the one difference of importance in the successions is that I place as a part of the Animikie the Upper Kaministiquia and equivalent rocks. These Lawson would regard as a part of his Keewatin. But he appears to have overlooked the fact that I distinctly suggest that between these series there may be an additional unconformity.†

Lawson objects to my placing the Keewatin as post-Archean and the Coutchiching as Archean on the ground that both of these have been intruded by subsequent granite-gneiss which he has denominated Laurentian. It is wholly new to me that an intrusive which cuts two prior series of rocks can give information as to the structural relations and relative ages of those two series. Dr. Lawson would hardly think of binding with the Triassic of Connecticut and New Jersey the adjacent pre-Cambrian crystalline rocks because they are both cut by numerous dykes of the same age.

On the south shore of lake Superior it has been repeatedly maintained by Brooks, Pumpelly, Irving, Chamberlin, and others, that the clastic series rest upon a thoroughly crystalline granite-gneiss-schist complex with an intervening great unconformity. In this part of the lake Superior region, from their point of view, subsequent to a portion of the clastics, there have also been granitic and gneissic intrusions. Northwest of lake Superior, Lawson's work has shown that similar intrusives cover large areas and include much of what has there been designated as Laurentian. Agreeing with Foster, Whitney, Wadsworth, Herrick, and the published reports of Rominger, Lawson has generalized as did some of these writers, that because a part of the granite-gneiss is intrusive later than the sedimentaries, it is all of this origin.

From recent work of others, the manuscript report of which I have seen, it appears probable that Lawson has overlooked that northwest of lake Superior, as on the south shore, and not far from Rainy lake, there is also a granite-gneiss-schist complex which is more ancient than and served as a basement upon which the fragmentals were deposited. This oversight may be due either to the fact that this basement complex does not appear in the districts which Lawson has studied in detail, or possibly cleavage may be so prominently developed in these districts as to have made it difficult to discover these relations. Because a part of the granite-gneiss northwest of lake Superior is an intrusive, is no evidence that another part of it is not more ancient than any of the sedimentaries. Thus, notwithstanding Lawson's surprise, I think that there still is found a large part of the preexistent basement in the Lake Superior region upon which the clastic series were deposited, a position which I do not hold dogmatically, but as according best with present evidence. The problem from my point of view is simply more complex than Lawson has believed. All of his facts are true, as well as the like facts of Foster, Whitney, and others, and there is the additional great fact of a granite-gneiss-schist complex more ancient than the recognized clastic

*Ibid, p. 134. †Ibid, p. 126.

series, as shown by Brooks, Pumpelly, Irving, and others. It is only when Lawson carries the facts of the districts which he has studied in detail (about 2 square degrees) over the entire Lake Superior region (30 or more square degrees), assuming that all of the coarse, banded, intricately contorted granite-gneiss is of the same age and origin as the somewhat regular granite-gneiss with which he is most familiar, and is consequently later than the clastic series, that I do not follow him. In short I accept the facts of both schools, but decline to apply the facts of one to the entire region to the exclusion of those of the other.

It seems to me that my mistake has been in using the word Coutchiching to designate the schists of this most ancient schist-gneiss-granite complex. To this conclusion I had come before Dr. Lawson's criticism was published, and had determined in a forthcoming discussion of the pre-Cambrian of America, of which my paper was a condensed statement of a small part (and therefore gives the evidence imperfectly), to discard the term Coutchiching for this place. By thus avoiding the implication that the Coutchiching is a part of the basement complex this series will be left to fall in its proper place as future investigation shows it to belong, and if it proves to belong to this fundamental complex, Coutchiching will of course apply to its schists. In the meanwhile there will result no such confusion as has come from the application of Coutchiching to the schistose part of this fundamental complex.

In this connection the question arises as to the use of the term Laurentian. Shall it be restricted to the basement granite-gneiss, or shall it include the whole granite-gneiss-schist complex prior to the clastic series, or shall it also include the granite-gneiss of later age which Foster and Whitney call intrusive, which Rominger calls Huronian, and Lawson calls Laurentian, and which he has supposed is the only Laurentian? From my point of view it certainly cannot be applied to the last class alone, and any one of these usages of it is a radical deviation from the original application of the term. Logan's descriptions of his typical areas (Ottawa and Grenville), clearly show that this Laurentian is largely a bedded series of unquestionable detrital origin, consisting in large part of limestones, quartz-schists, quartzites, and even conglomerates. But the question as to the proper use of Laurentian is one which I avoided raising in my paper because I knew it was one upon which there would be difference of opinion. Lawson's article forces a statement of the question even if space does not permit an attempt to answer it.

Lawson objects to my use of the term Archean. It may be suggested in return that if my use of this term is open to criticism, Lawson's use of Algonkian is perhaps equally open to attack. This is a term introduced by the United States Geological Survey as a period term standing equivalent to Agnotozoic, proposed by Irving, to include pre-Paleozoic clastic series, not of the Lake Superior region alone, but for the whole United States; yet Lawson places the whole Algonkian as Paleozoic, without any reference to its original definition or to its use in previously published articles.

But space will not here permit a defense of my major taxonomy. As has been indicated, my paper was but a part of a more extended discussion to appear in a forthcoming bulletin of the U. S. Survey, and I shall have to be content to let the case rest until this paper is published. The object of my article was to emphasize points of agreement as to actual rock successions in the Lake Superior region; the object of this note is to show that Dr. Lawson and I are mainly in harmony in this respect. In the matter of major taxonomy it is evident that there is a difference of opinion. It is a case of disagreement as to what will best advance the geology, not only of the Lake Superior region, but of America as a whole. C. R. VanHise.

Madison, Wis., May 9, 1891,

The Appropriation for the Missouri survey. I notice on p. 270 of your issue for April, that you spoke of an appropriation of $40,000 *per year* being made for this survey. I have seen this statement in other publications and do not know exactly how it arose. The appropriation which has been made for us is $40,000 for *two* years, and we have to defray the expenses of publication out of this, so that this is altogether a moderate sum, I agree with you that a small and continuous appropriation is a desideratum for the future, and I recognize that we cannot expect to secure large appropriations for many years in succession. There is, however, certain fundamental work yet to be done in this state, which I wish to push to completion as soon as possible; after this is done, the small continuous appropriations will be all that is necessary, it seems to me, to maintain the survey as an efficient organization. Arthur Winslow.

Jefferson City, April 13, 1891.

Dr. Carpenter's reply to Mr. S. A. Miller.

The American Geologist for July, 1890, contains two letters by Mr. S. A. Miller of Cincinnati, in reference to a review of his "North American Geology and Palæontology" which had appeared in the *Annals and Magazine of Natural History* for the previous April. Mr. Miller was not pleased with this review, which he called "a false, malicious and libellous article," and he wrote a letter about it to the editor of the *Annals*. But instead of sending it direct to them, he asked Messrs. Dulau of London, who had purchased some copies of his book, to forward it to him. The terms of the letter, which was subsequently published in your columns, were somewhat violent; and as Messrs. Dulau desired to keep out of other people's quarrels they returned the letter to Mr. Miller, and advised him to send it direct to the editors of the *Annals*. This, however, he neglected to do, and yet he now states that the letter was returned to him "with a refusal to publish it;" while he further comments on the "disingenuous management" of the *Annals*, and "its subserviency to those nearest home." These statements, like many others which Mr. Miller has made, have no foundation in fact. For his letter never reached the editors of the *Annals* at all; and he cannot therefore have any grounds of complaint against them about it.

Mr. Miller has promised on some future occasion to "make known the motives that actuated the unwarranted attack, as I recognize the author as well by his feet tracks, as I would if his signature had appeared with the middle name at full length as usual.'

It is well known to those who are acquainted with Crinoid literature, that this passage refers to me. But Mr. Miller is entirely mistaken; for I neither wrote the review in question, nor did I know anything about it till some time after its publication.

As, however, Mr. Miller imagined me to be the author of it, the intemperate violence of his personal attact upon me in the November and December numbers of the AMERICAN GEOLOGIST may be readily understood. We have unfortunately differed upon a small point of nomenclature, Mr. Miller preferring the empirical, and I the rational terminology. The latter is in general use in Europe and Australia; and it has been gradually adopted in America by Messrs. Wachsmuth and Springer, A. G. Wetherby, H. S. Williams, C. D. Walcott, A. H. Worthen, W. R. Billings, E. N. S. Ringueberg, J. F. Whiteaves and A. Agassiz. I am not aware that any American palæontologists have used the old and purely empirical nomenclature during the last eight years, with the exception of Mr. Miller and his collaborator, Mr. Gurley, who are, therefore, in a somewhat isolated position; and this may perhaps account for the tone of Mr. Miller's remarks upon the subject in pages 279-281 of your November number. Among these remarks there is one statement which is so absolutely untrue that I must ask you to allow me to contradict it. According to Mr. Miller, I have said that the so-called subradial plates of palæocrinoids are "the genital plates," an assertion which he calls "purely gratuitous, and not warranted by any of the known facts relating to crinoids." This criticism was not necessary, as the assertion in question was never made. But like many other morphologists and palæontologists I have described the so-called subradial plates of crinoids as homologous with the so-called genital plates of urchins; and this may perhaps account for Mr. Miller's very incorrect reference to the subject. It is useless, however, to look for a proper understanding of the morpholgical questions which are here involved, or even of the meaning of the word "homologous," on the part of an author whose zoölogical knowledge is so limited that he tells his readers that the sponges "are not to be regarded as any more highly organized than the Rhizopoda."

Mr. Miller's acquintance with recent publictions on the subject of the Crinoidea is equally defective. On page 356 of your December number he quotes against me an opinion of Wachsmuth and Springer's to the effect that they do not understand how the five summit plates of *Haplocrinus* can represent the orals of a palæocrinoid; and he briefly adds, "Neither does any other one."

It is a pity that Mr. Miller should have committed himself to such a very positive statement; for it is not true. If he will consult the well known text books on palæontology by Zittel, Hœrnes, Steinmann, and Nicholson, and also Neumayr's important work "Die Stämme des

Thierreiches," he will find that the five summit plates of Haplocrinus are invariably regarded as orals. But this is not all. Although Messrs. Wachsmuth and Springer could not accept this view in 1886, they found reasons for changing their opinions two years later. In the Proceedings of the Academy of Natural Sciences of Philadelphia, for 1888, they published a paper entitled "Discovery of the ventral structure of *Taxocrinus* and *Haplocrinus*, and consequent modifications in the classification of the Crinoidea." Mr. Miller is evidently not acquainted with the contents of this important paper. For on page 350 the authors say, "We must admit the weight of the evidence is in favor of the supposition that the plates covering the ventral surface in *Haplocrinus* and *Aallagecrinus* are orals." Mr. Miller, however, seems to have remained in total ignorance of the fact that Wachsmuth and Springer had written anything fresh upon the subject of *Haplocrinus* since 1886; while certain passages in his definitions of the families Ichthyocrinidæ, Taxocrinidæ, and Platycrinidæ, show him to be equally unacquainted with the recent discoveries of his fellow country men, though they were published nearly two years before he wrote, and have a most important bearing on the systematic arrangement of the Crinoidea, as indeed is implied in the title of the paper in question. The result is that he has produced a classification of the group, of which it is scarcely too much to say that, like his use of the term "subradials," it was out of date before it was published.

P. HERBERT CARPENTER.

Eton College, Windsor, England, April 20, 1891.

A CORRECTION. By an error in my paper on *Lake Superior Stratigraphy*, the word "younger" appears instead of "older" in the eighth line from the bottom on page 322 of the AMERICAN GEOLOGIST for May, 1891. ANDREW C. LAWSON.

Berkeley, May 8th.

PERSONAL AND SCIENTIFIC NEWS.

DR. HANS REUSCH HAS RECENTLY FOUND, on the north side of the Varanger fiord in northeastern Norway, glacial striæ and a formation which was originally boulder-clay or till, belonging to a period much older than the Ice age of the Quaternary era. The series of sandstones and conglomerates presenting these proofs of former glaciation are regarded by Dahll as Permian, but Dr. Reusch thinks that they may be a part of the Cambro-Silurian system which chiefly makes up the Scandinavian mountains. The paper contains excellent photographic illustrations of striated rock fragments from the conglomerates, and of the striæ and grooves on the underlying sandstone. There were two courses of glacial movement, the principal one being towards the southeast,

crossed by another towards the east. The Quaternary glaciation of this district was from southwest to northeast. If the ancient glacial period was Permian, it was probably contemporaneous, or nearly so, with the Permian and Carboniferous glaciation of portions of Great Britian and Central Europe, and of South Africa, India, and Australia, as reviewed in the GEOLOGIST, May 1889.

THE LAST LEGISLATURE OF THE STATE OF WASHINGTON, appropriated fifty thousand dollars for a geological survey of the state.

AT THE MEETING IN WASHINGTON, on April 21, 1891, of the committee on organization of the International Congress of Geologists, the following communication was received:

February 28, 1891.

PROF. H. S. WILLIAMS,

Sec'y of Com. of Organ, Intern. Cong. Geologists.

Dear Sir:—The undersigned, feeling that with their radically different views from the majority of their colleagues of your committee, on the most important questions concerning the coming session of the International Congress of Geologists, they cannot aid the said majority in any way in the work of preparation therefor, hereby offer their resignations from the committee of organization. Very truly,

T. STERRY HUNT,
PERSIFOR FRAZER,
E. D. COPE.

Since that date Prof. Joseph Leidy and Prof. Angelo Heilprin, both formerly Philadelphia members of the committee on organization, have ceased to be such, the first through his lamented death and the second by resignation.

RATE OF CORAL GROWTH.—PROF. HEILPRIN (Proc. Acad. Natl. Sci. Phila., Jan. 27th, 1891) states that from observations recently made in the harbor of Vera Cruz, Mexico, the annual accretion of *Porites astæoides* is somewhat less than one twentieth of an inch. Observations on other species of corals have yielded similar results.

AQUEOUS ORIGIN OF GOLD.—Some of the great gold quartz veins of Australia, are considered by very high authorities to have been formed from a deposition of quartz and silica, by condensation from an aqueous solution of an alkaline silicate of gold. The microscopic researches of both Sorby and Howitt, have shown that in the minute cavities of vein-silica, or in crystals of quartz, an aqueous fluid has been found, which upon analysis has been shown to consist of water, holding sulphates and chlorides of potash, soda and lime in solution; and these substances are all, earth alkalies! Also, in this fluid found in the minute cavities of vein-quartz, even free sulphuric and muriatic acids have been found, thus giving rise to the former possible combination of an aqueous solution of an alkaline silicate of gold, with aqueous solutions of the hyposulphites and cholorides of gold, and the free acids being formed as soon as the conversion of the gold in the metallic state

took place. Following up this line of reasoning, every peculiarity of the genesis and structure of an auriferous or gold-bearing quartz vein can be explained, by presuming that the deposition of the quartz came from water which held alkaline silicates, salts and acids in solution, and precipitated them upon condensation of this aqueous solution, which was then followed with crystalization of the silica into quartz, and the silicated gold into metallic gold. And, in addition to these reactions, the associated minerals found in the veins of quartz with gold, may have evidently been derived from the very same sources.—*Dr. Willis Everette.*

It is to be hoped that the following extract from the *Cleveland Leader* does not represent the average condition of geological knowledge in the great state of Ohio, or at least among its legislators. It has long been known that the wise men came from the East, and Sidney Smith once said that he never realized this till he went west. It would seem that "gassing" should be the chief employment of the state geologist according to Mr. Brown.

Columbus, March 18.

Representative Griffin, of Lucas, has received a letter from representative Brown, of Hancock, asking for legislative action of a rather startling nature. Mr. Brown requests that Mr. Griffin introduce a resolution providing for an investigation of Hon. Edward Orton, state geologist, for stating in his last report that natural gas is failing in northwestern Ohio.

Dr. Ottokar Feistmantel of Prague, died on the 10th of February in the 43d year of his age.

Dr. Joseph Leidy, the eminent paleontologist, of Philadelphia, president of the Philadelphia Academy of National Sciences, died April 30, at his residence in that city.

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ERRATA.

Page 322, 10th line from the bottom for "younger" read older.

In the Mineral table, page 338, after Monazite read $1.811^{+13°}_{.046}$ yellow.

Insert a diæresis over the u of grünesite.

In the classification of rocks, under III. B. f. 3d, transfer the semicolon from before to after the word feldspar.

9 9